A PREDESIGN REPORT ON

MARINE WASTE DISPOSAL

VOLUME II DATA SUPPLEMENT

DEPT. OF
PUBLIC WORKS

CITY AND COUNTY OF SAN FRANCISCO

BROWN AND CALDWELL
CONSULTING ENGINEERS
SAN FRANCISCO

SEPTEMBER
1971

CITY AND COUNTY OF SAN FRANCISCO

A PREDESIGN REPORT ON

MARINE WASTE DISPOSAL

VOLUME II DATA SUPPLEMENT

OCEANOGRAPHIC AND ECOLOGICAL BASE DATA ACQUISITION AND EVALUATION OF ALTERNATIVE LOCATIONS.

SEPTEMBER, 1971

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November 8, 1971

F 236A

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PREDESIGN REPORT ON MARINE WASTE DISPOSAL

In accordance with our agreement for engineering services dated June 23, 1969, we submit herewith the final report on our studies of the feasibility of marine waste disposal in the waters of San Francisco Bay and the Pacific Ocean adjacent to the city. The report is presented in two volumes. Volume I contains the text of the report, together with explanatory graphs, tables and figures. Volume II presents the data which were collected in the course of the study, together with special reports on specific phases of the study program.

The basic finding of our two-year study is that primary effluent from the City of San Francisco, discharged at appropriate points through properly designed submarine diffusers, will not adversely affect the marine environment of the Central Bay or the Gulf of the Farallones.

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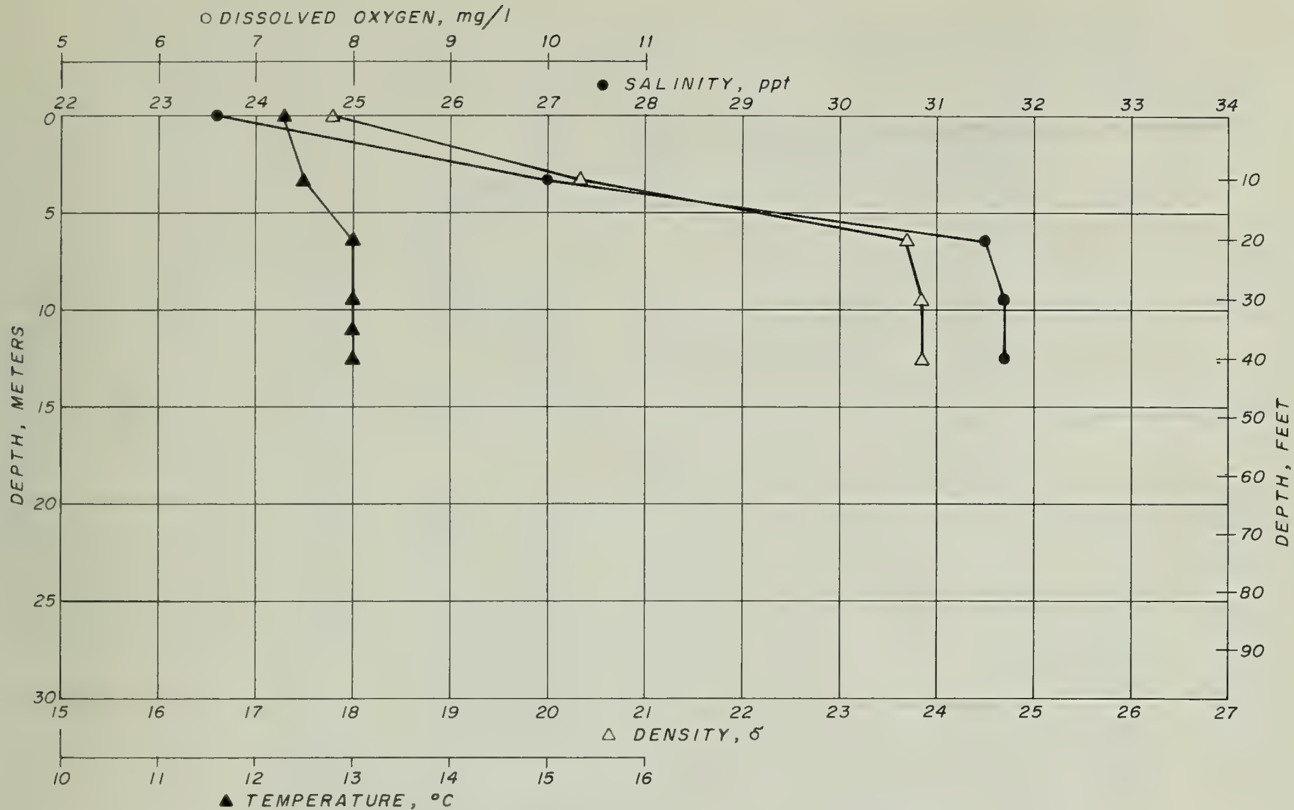

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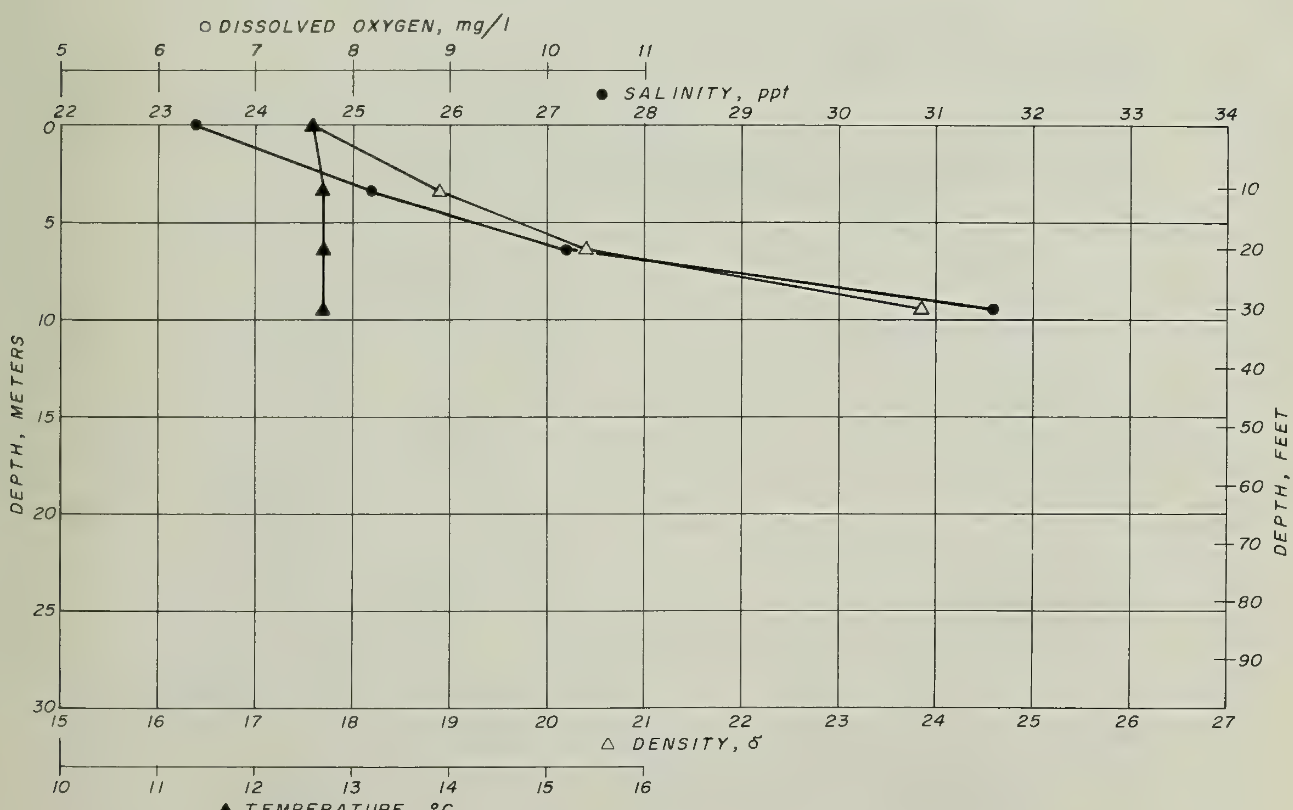

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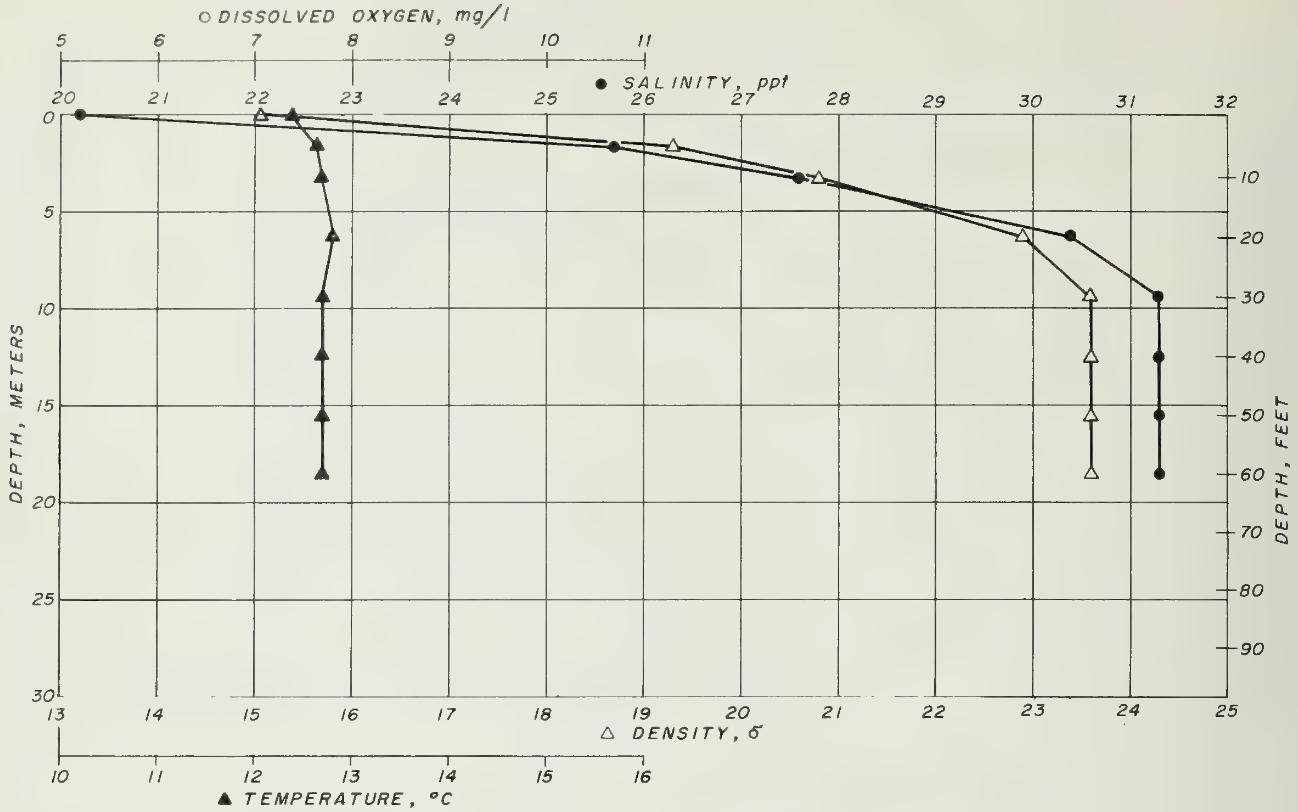

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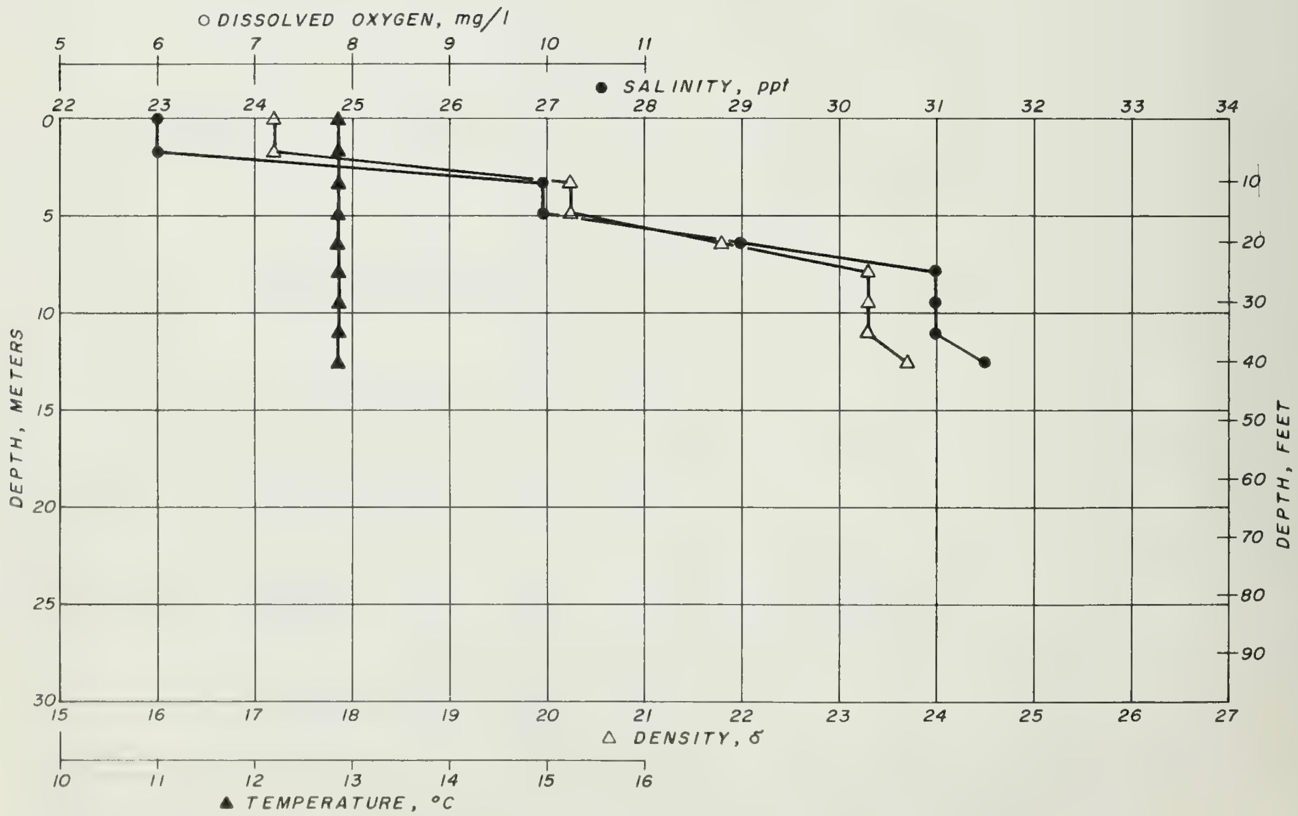

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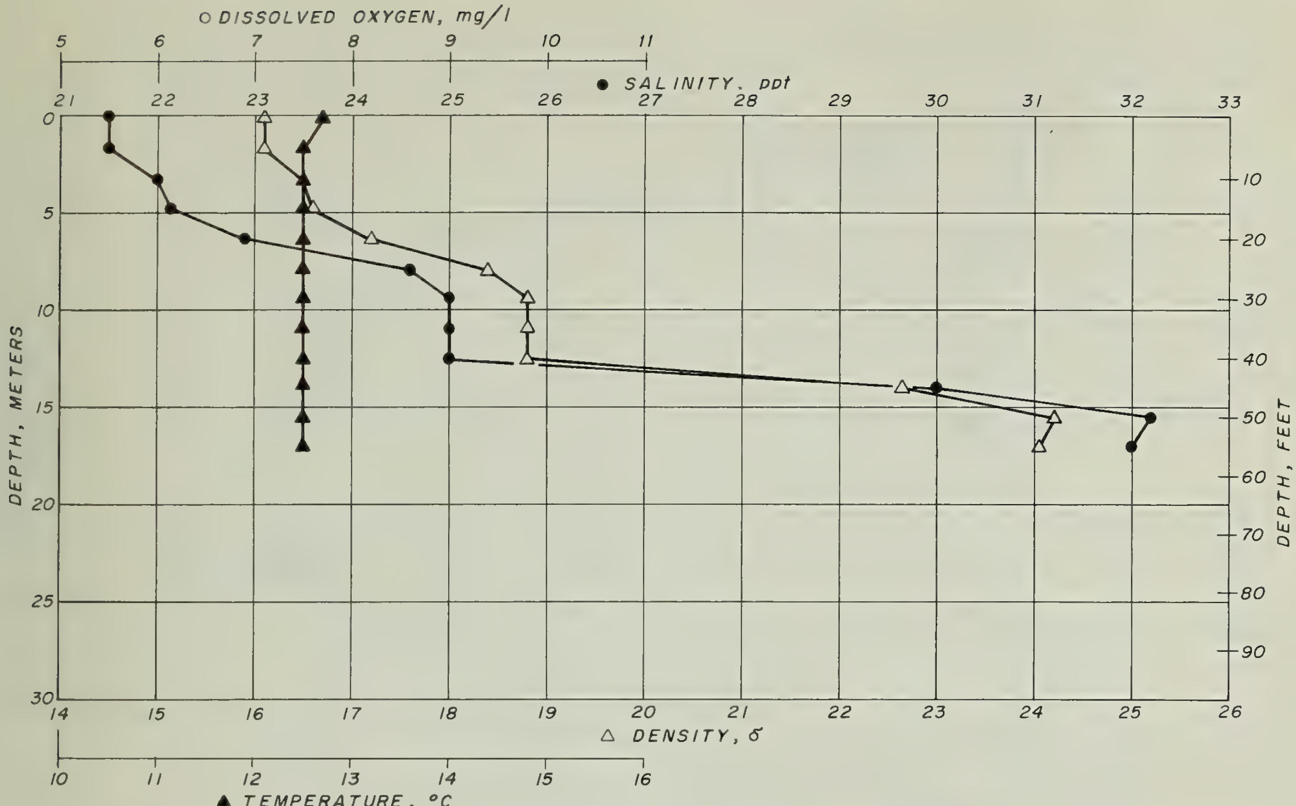

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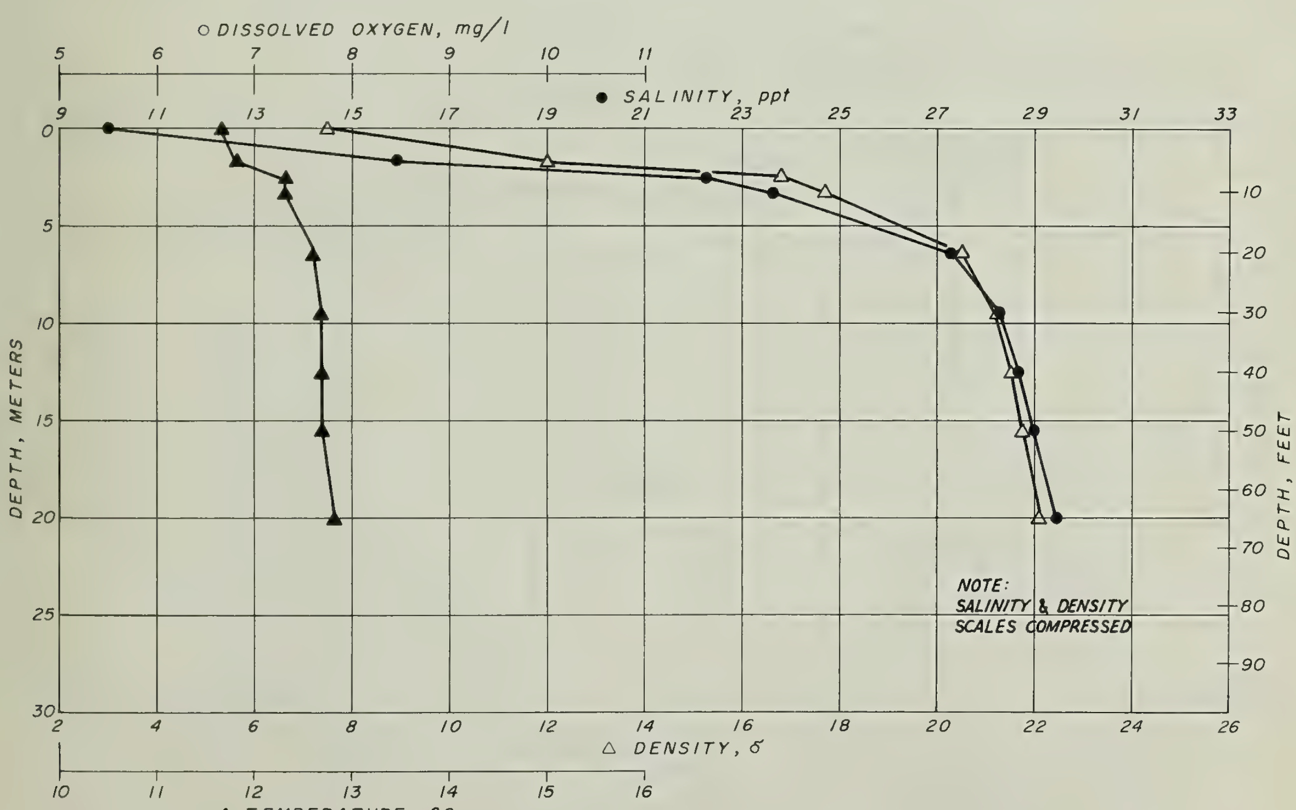

STATION 65 DATE 2/3/70 TIME 1235

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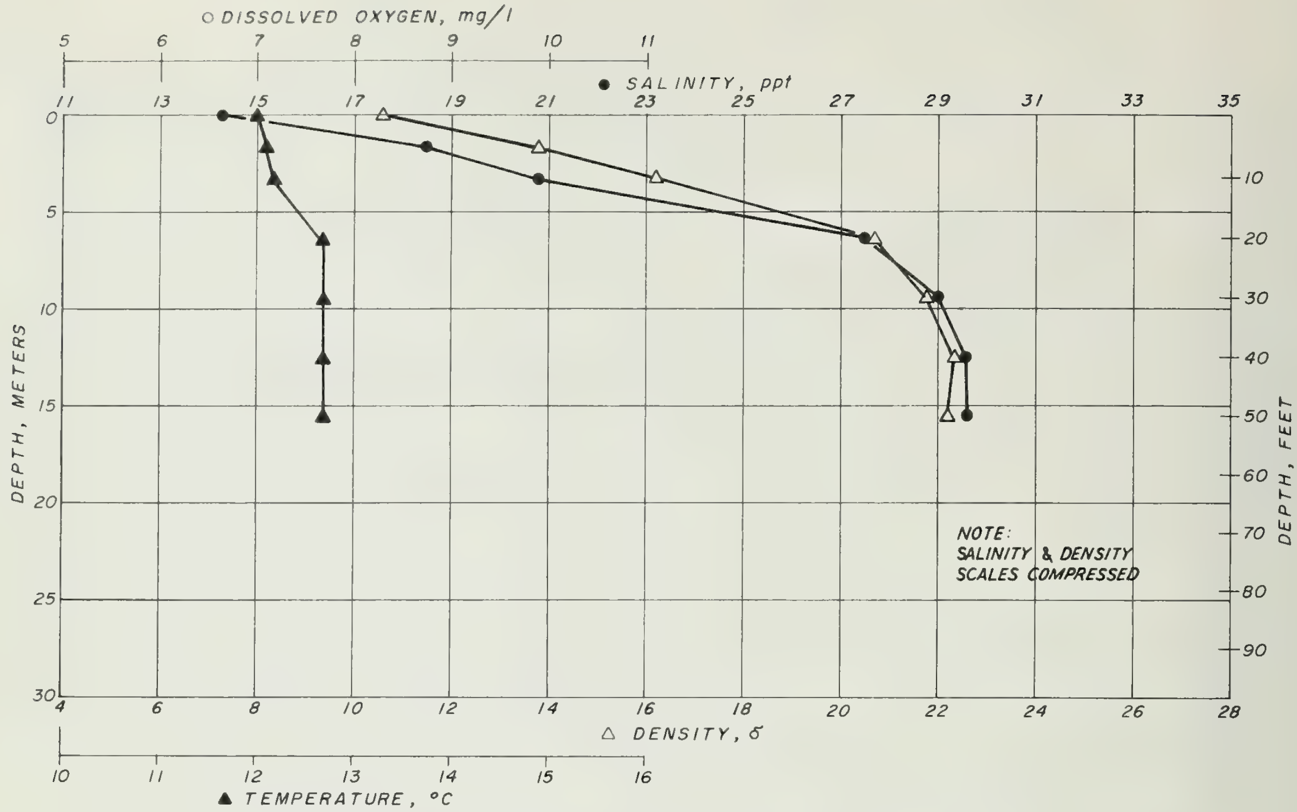

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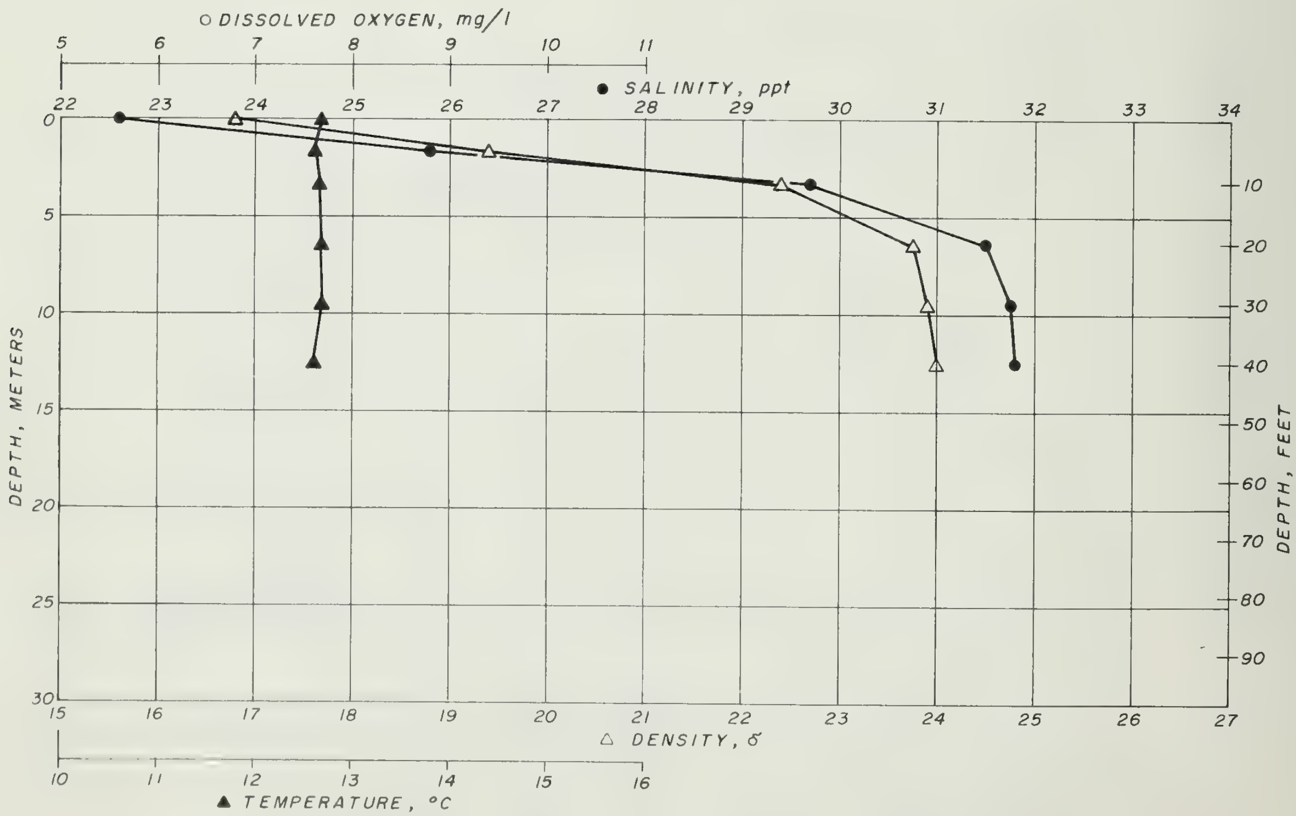

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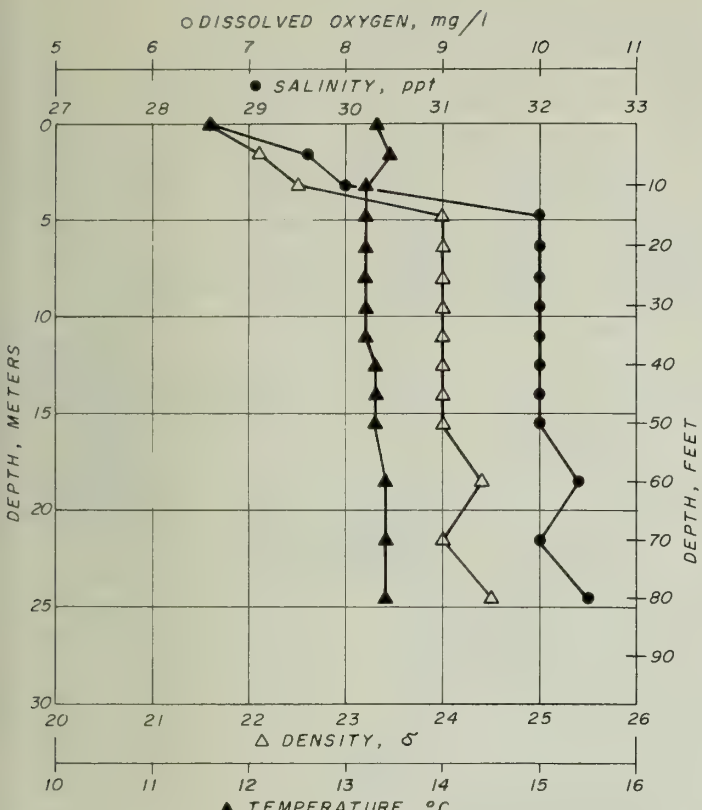

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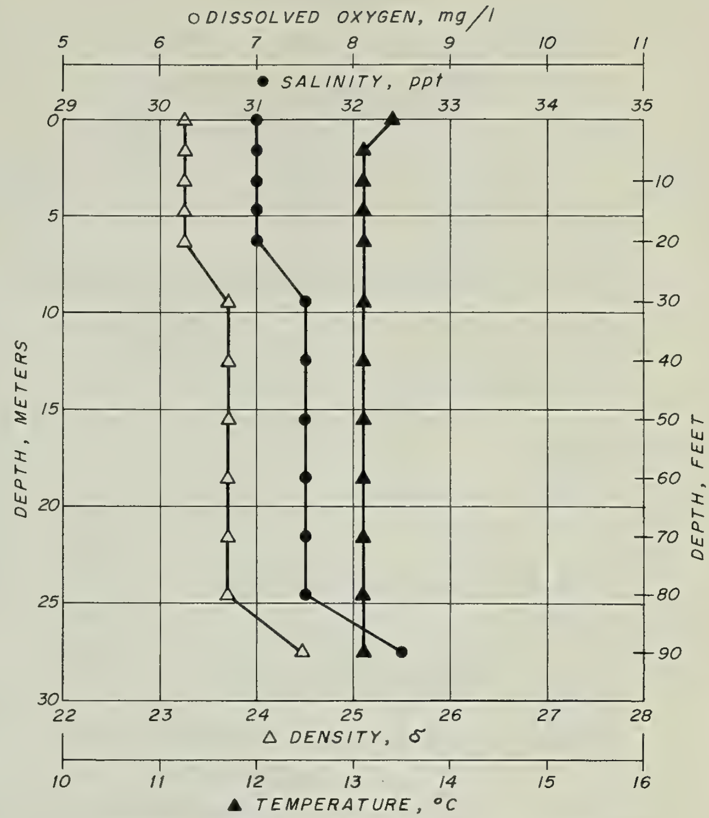

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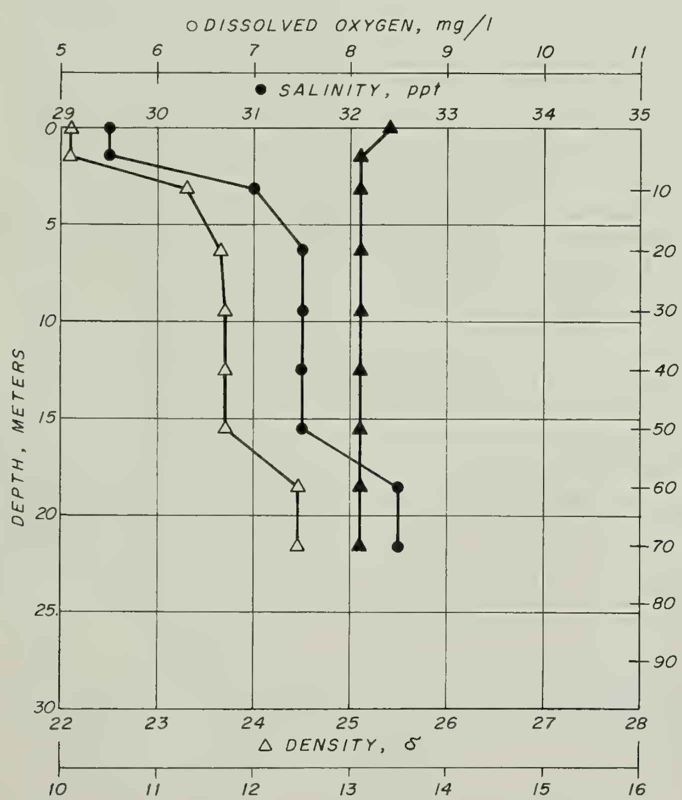

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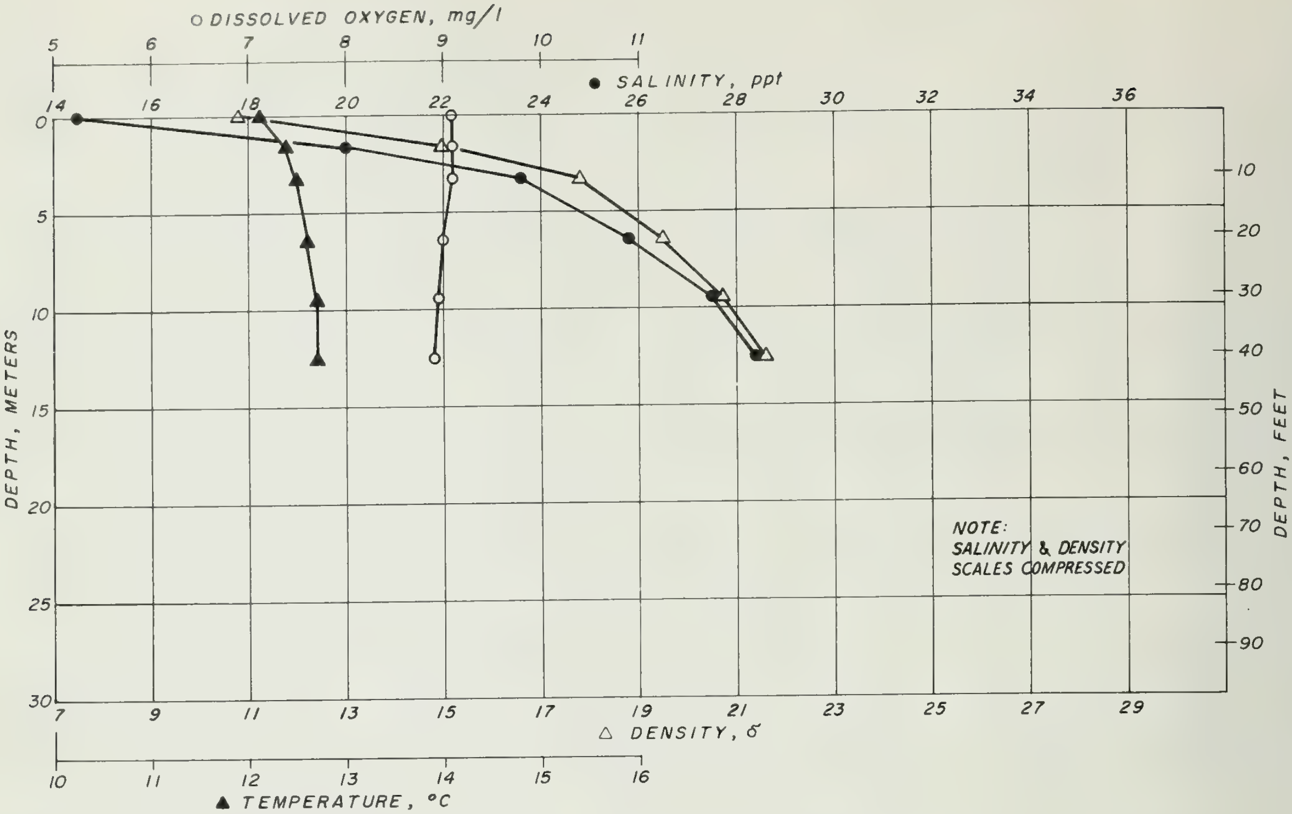

STATION 95 DATE 2/3/70 TIME 1610
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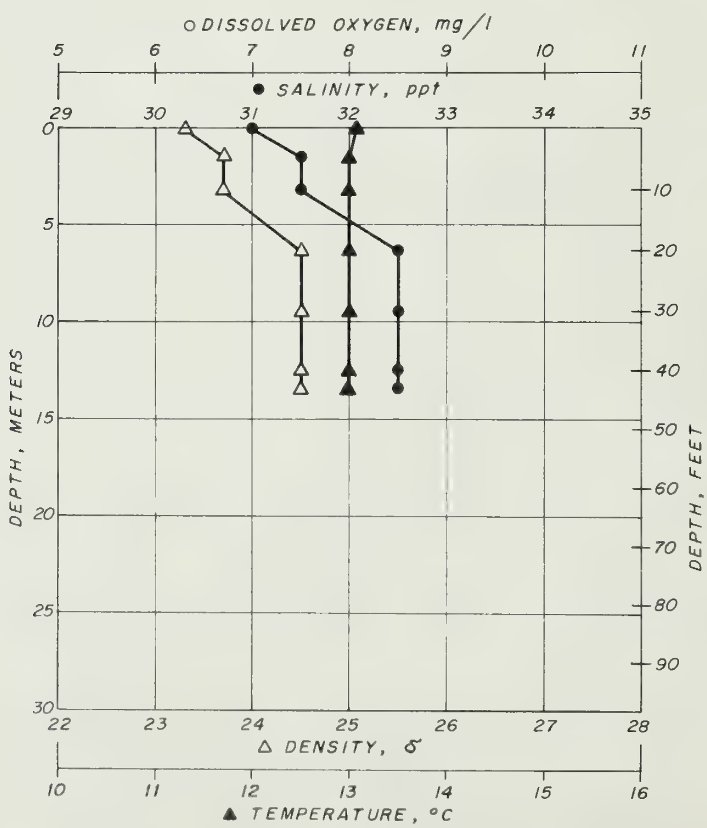

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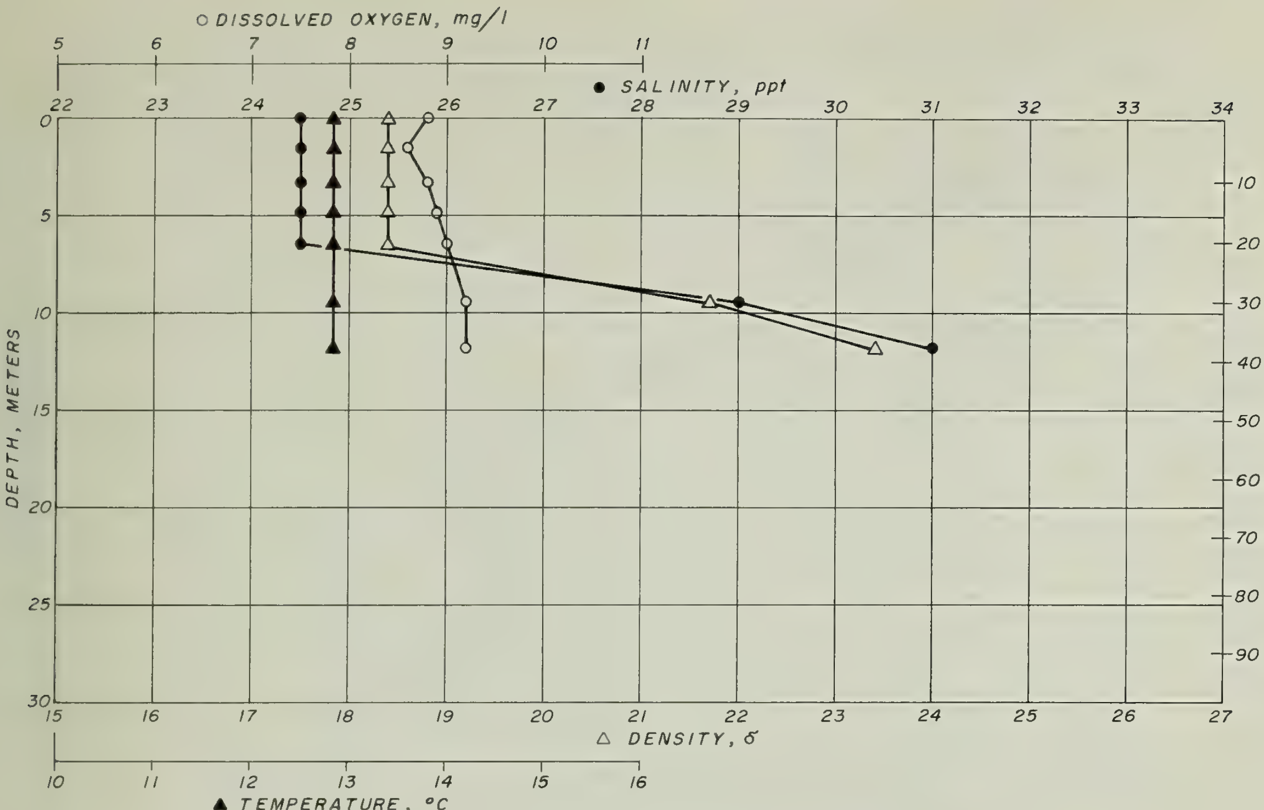

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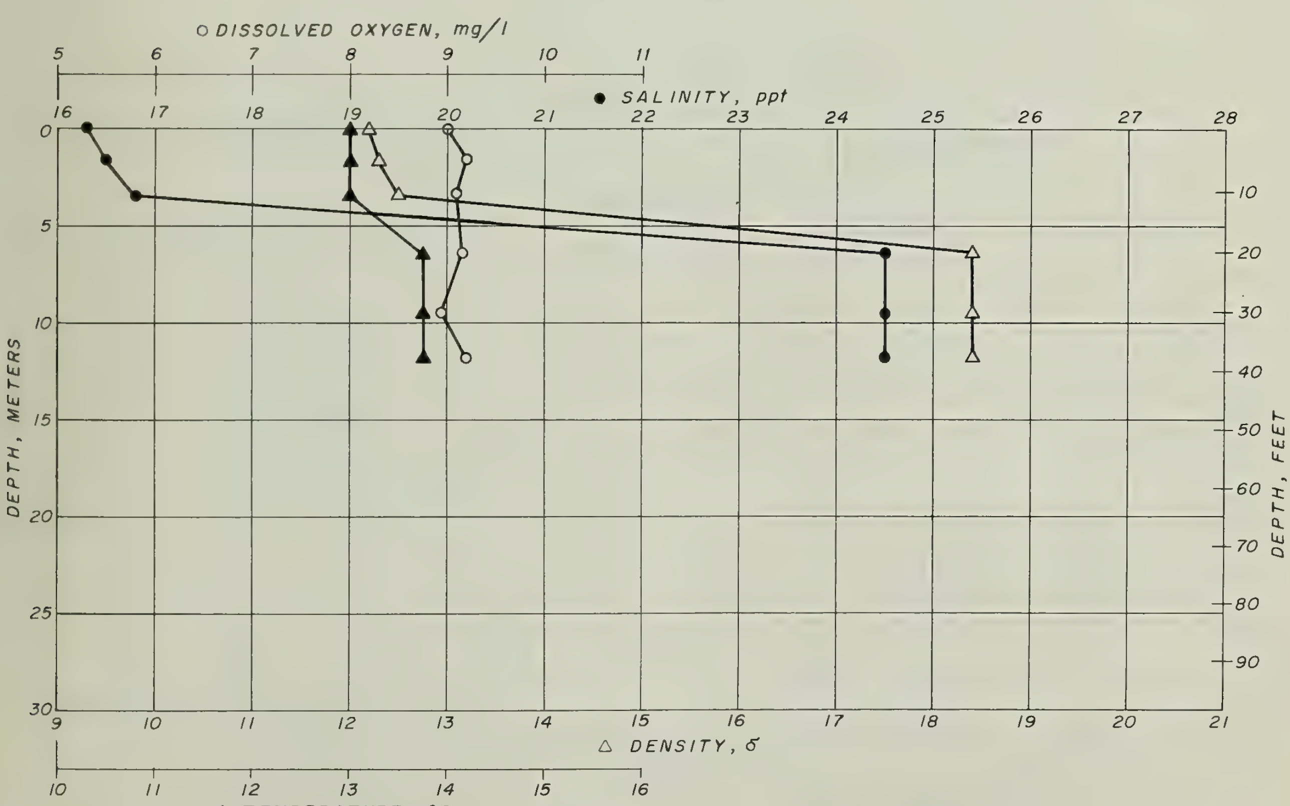

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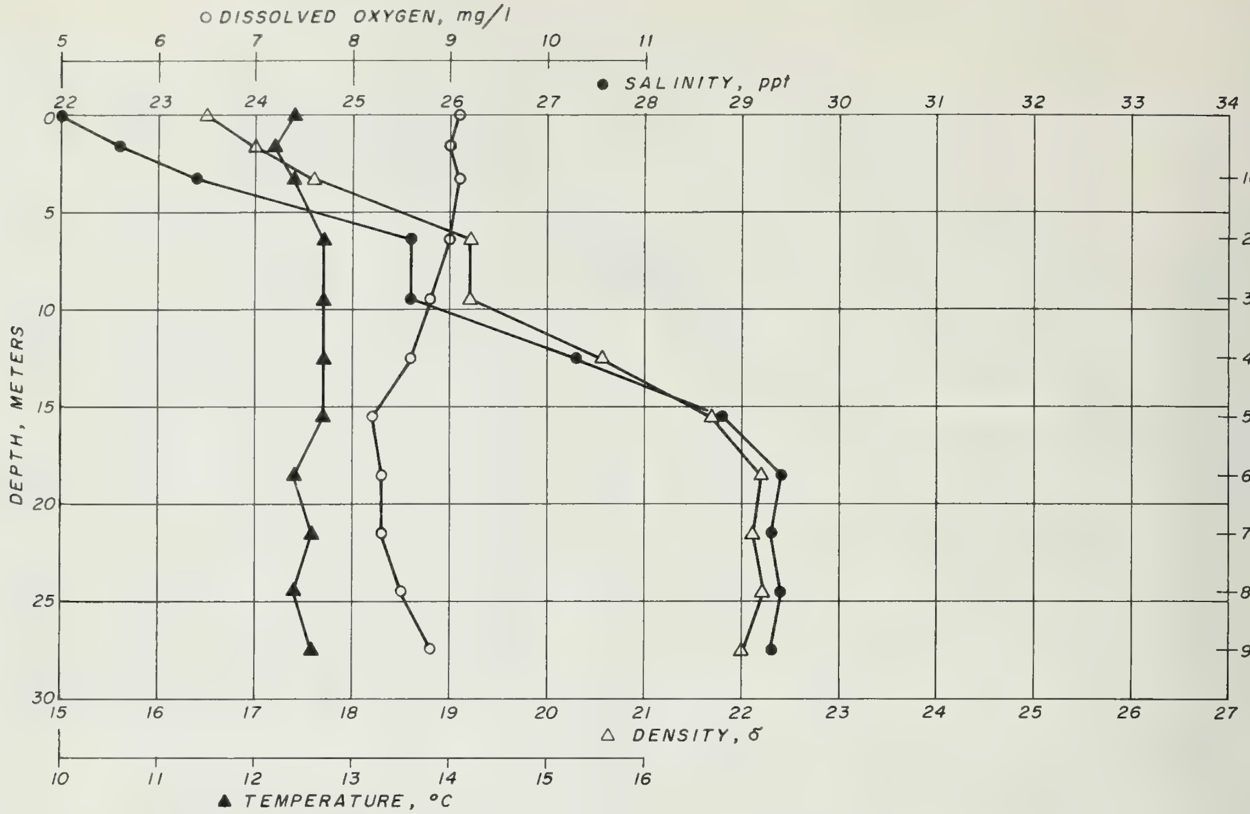

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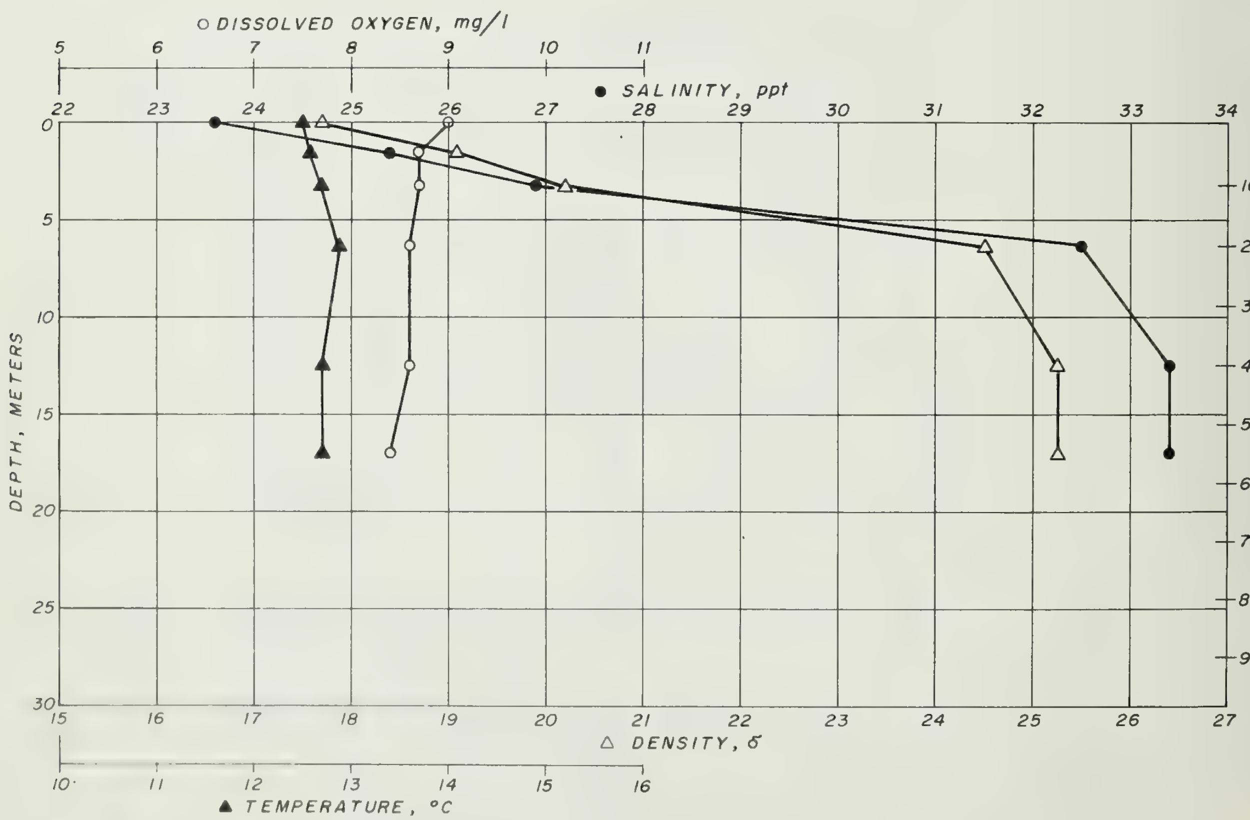

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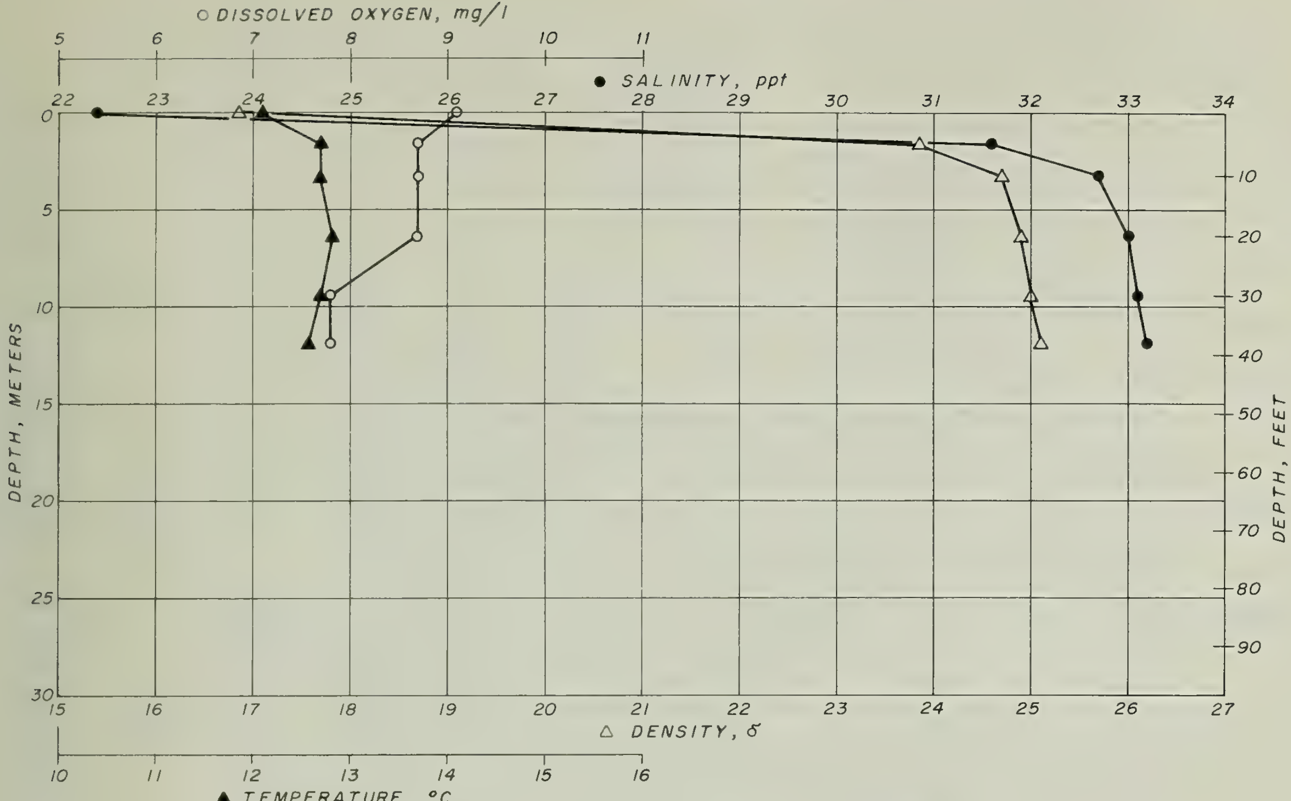

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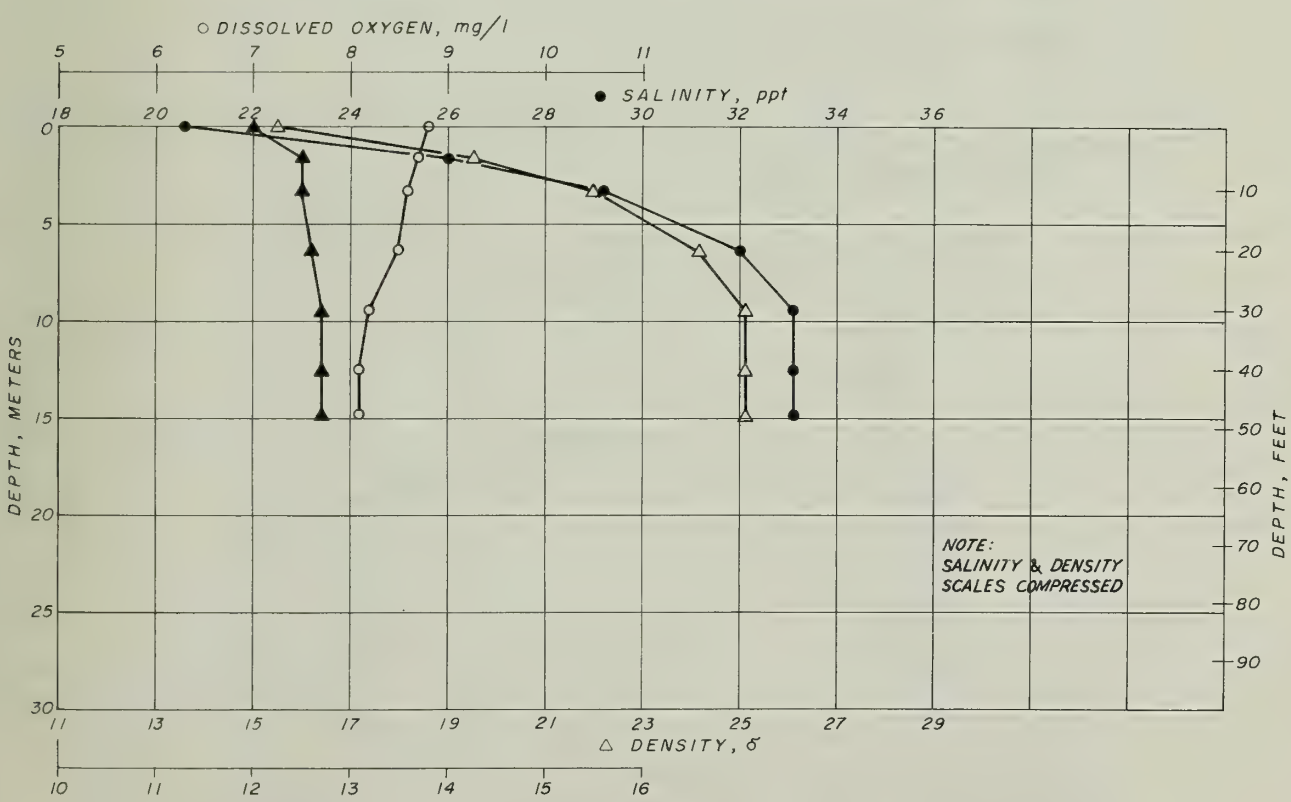

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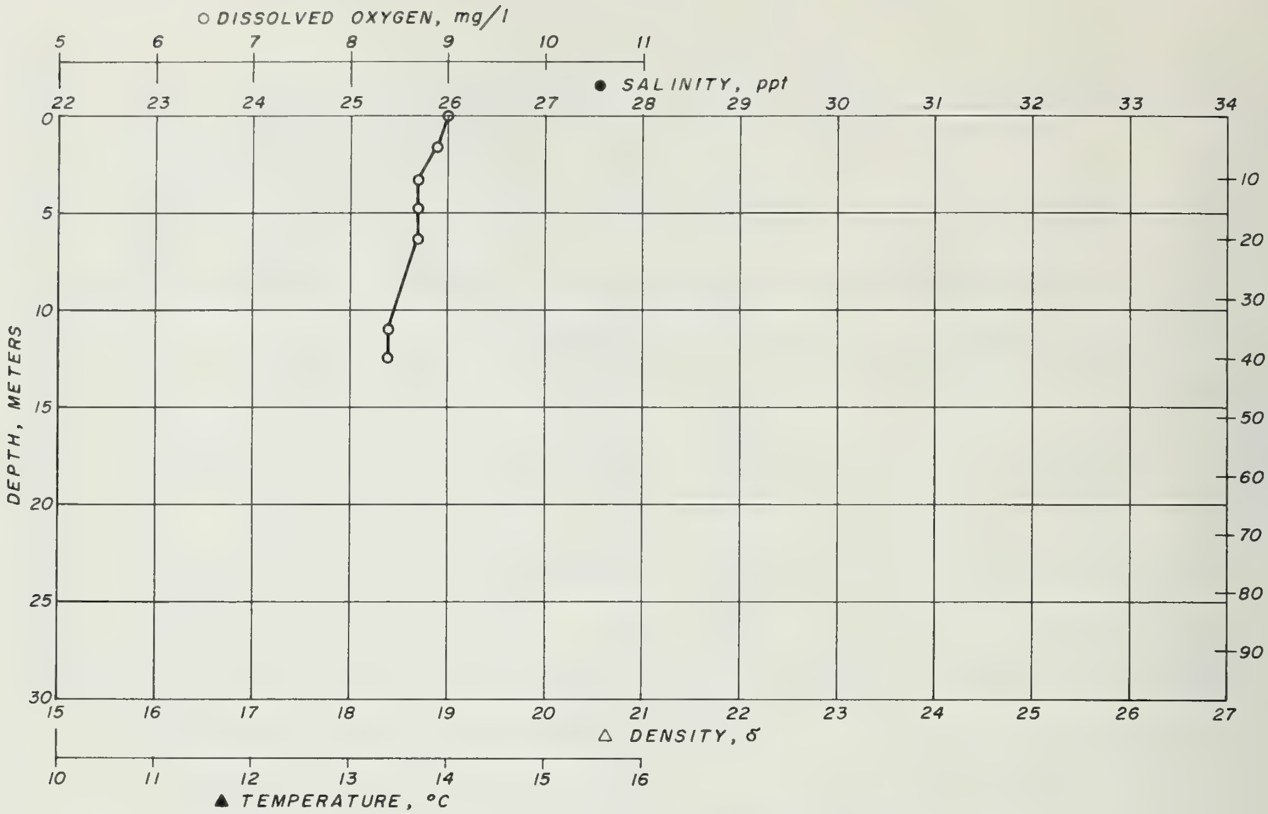
DEPTH, FT 50 REFERENCE FIG. 4-12



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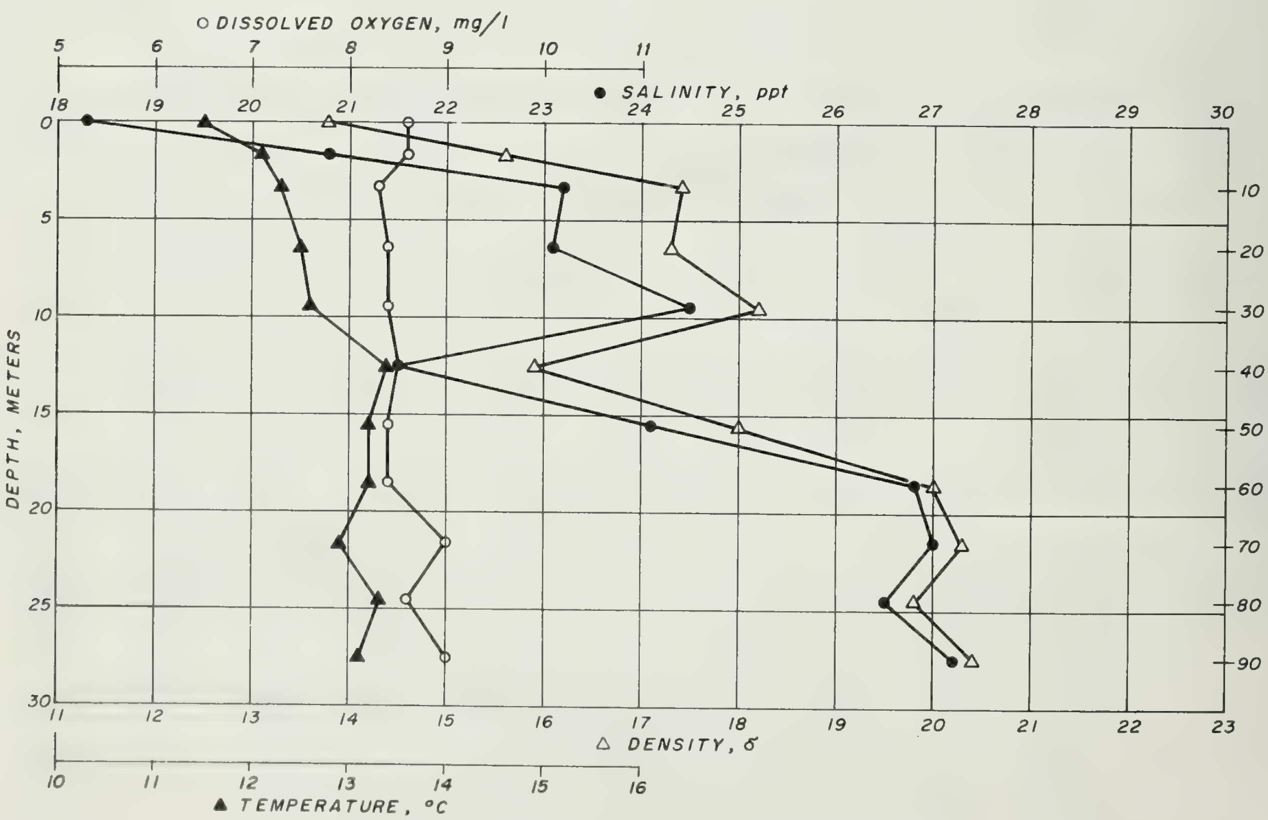

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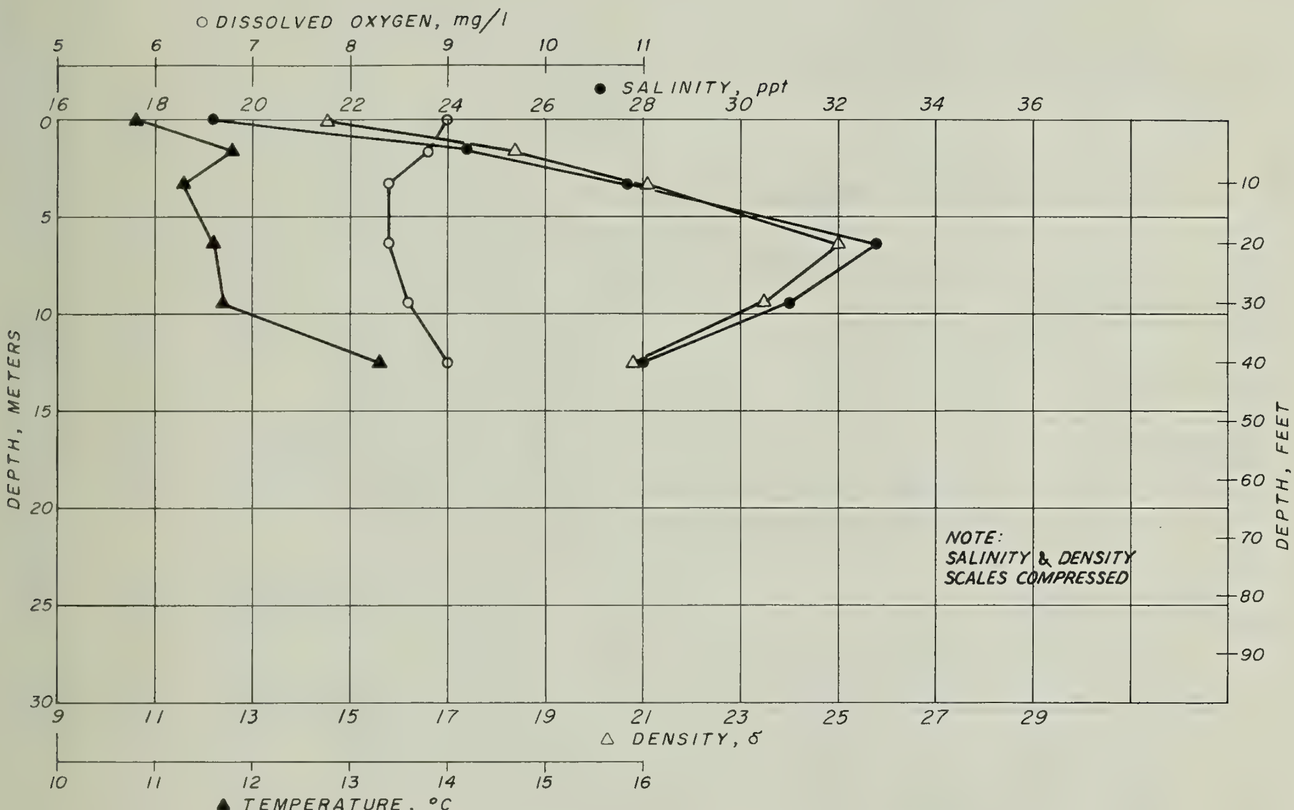
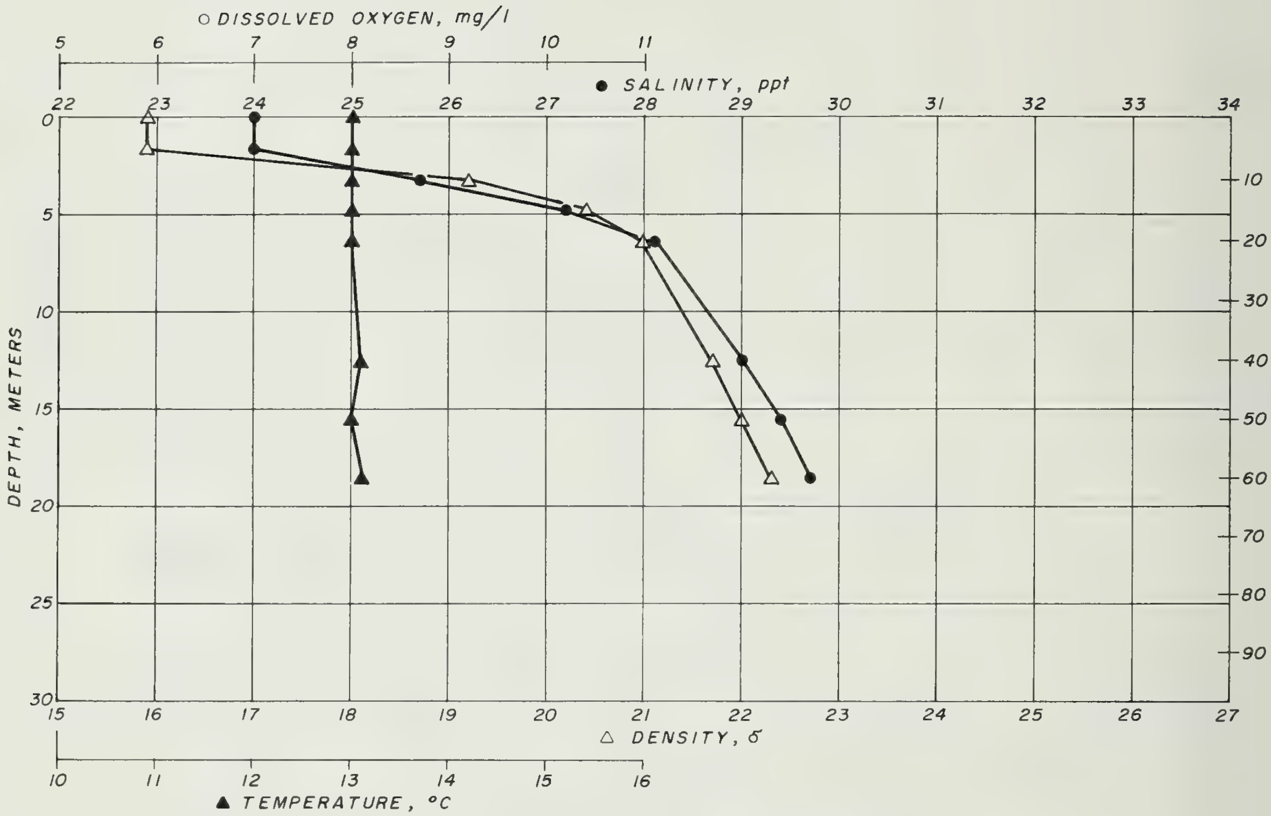


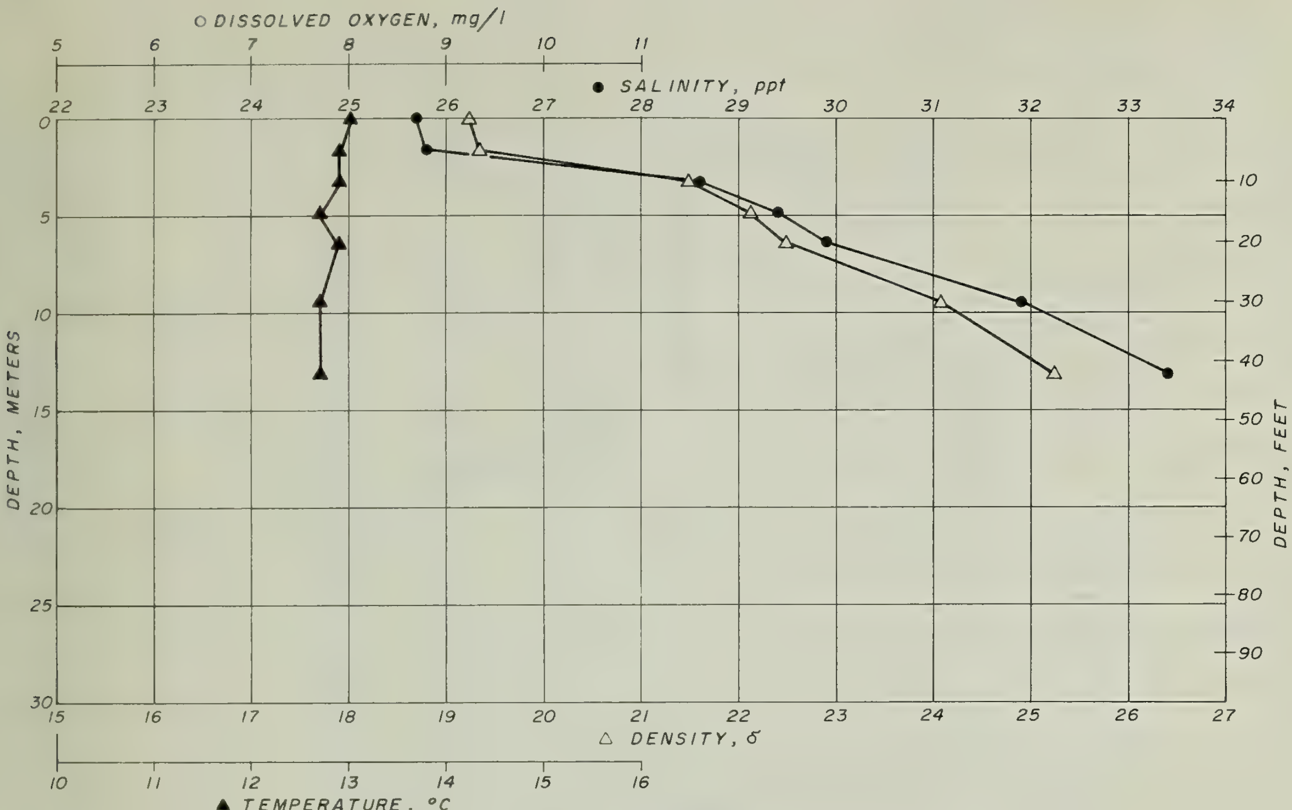
STATION 99 DATE 2/4/70 TIME 0240

DEPTH, FT 75 REFERENCE FIG. 4-12



STATION OCEAN DATE 2/24/70 TIME 0745

DEPTH, FT 75 REFERENCE FIG. 4-13



STATION OCEAN DATE 2/24/70 TIME 0905
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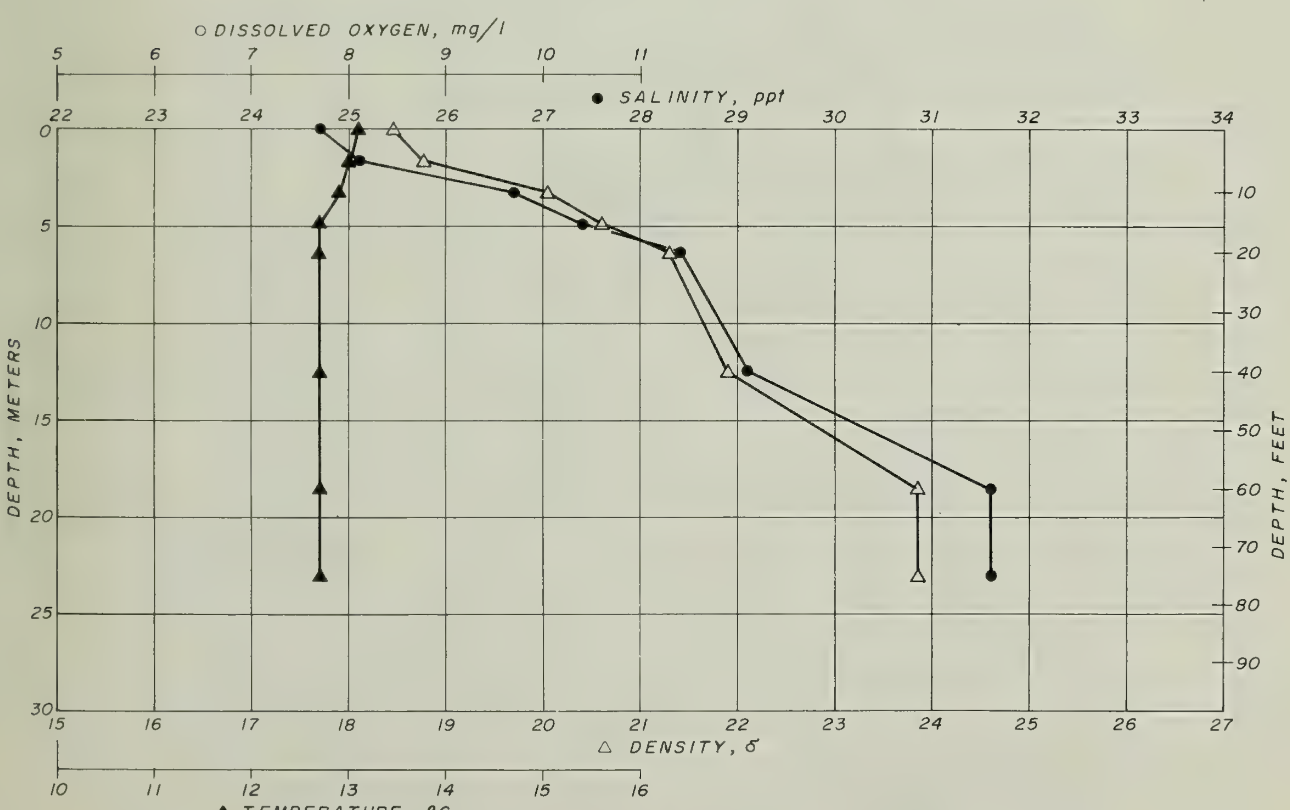

STATION OCEAN DATE 2/24/70 TIME 1145
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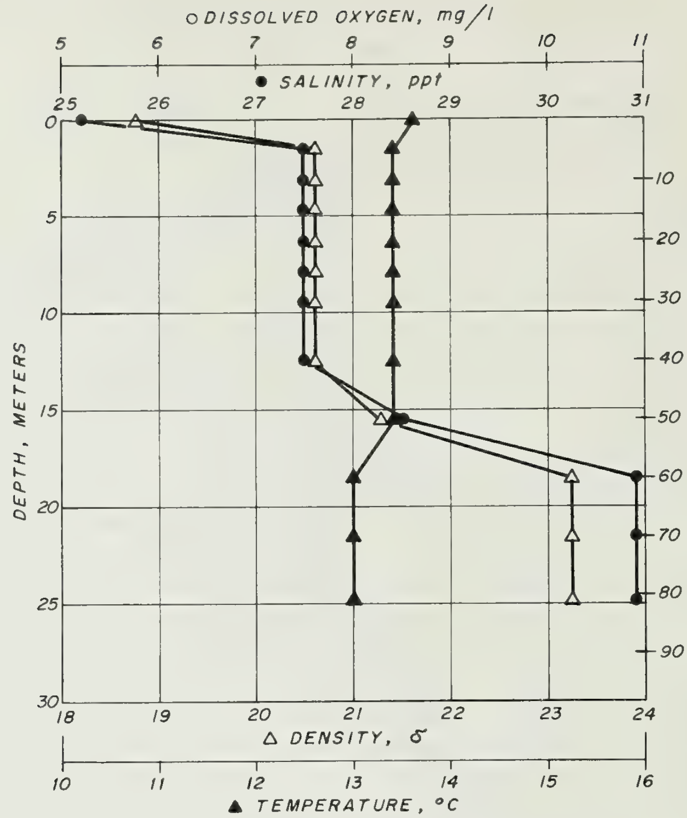

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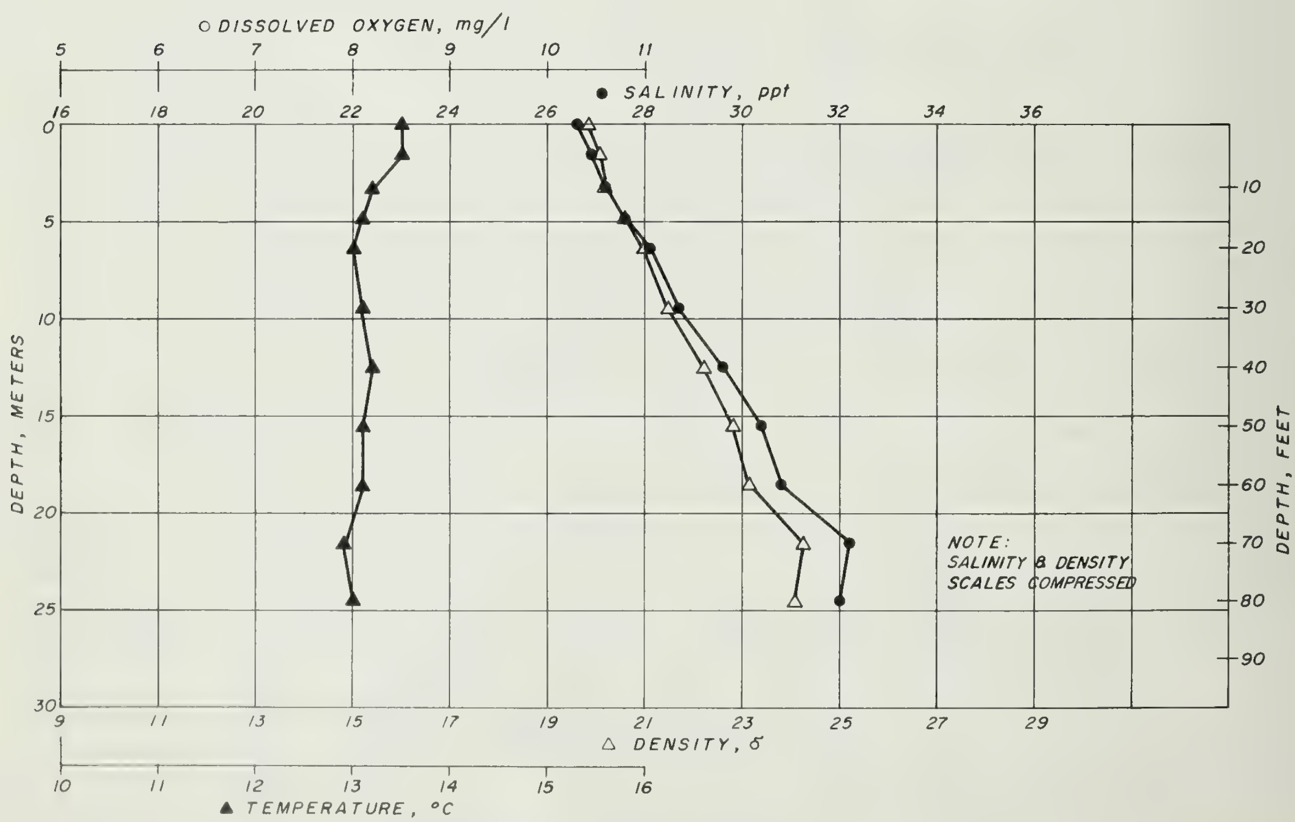

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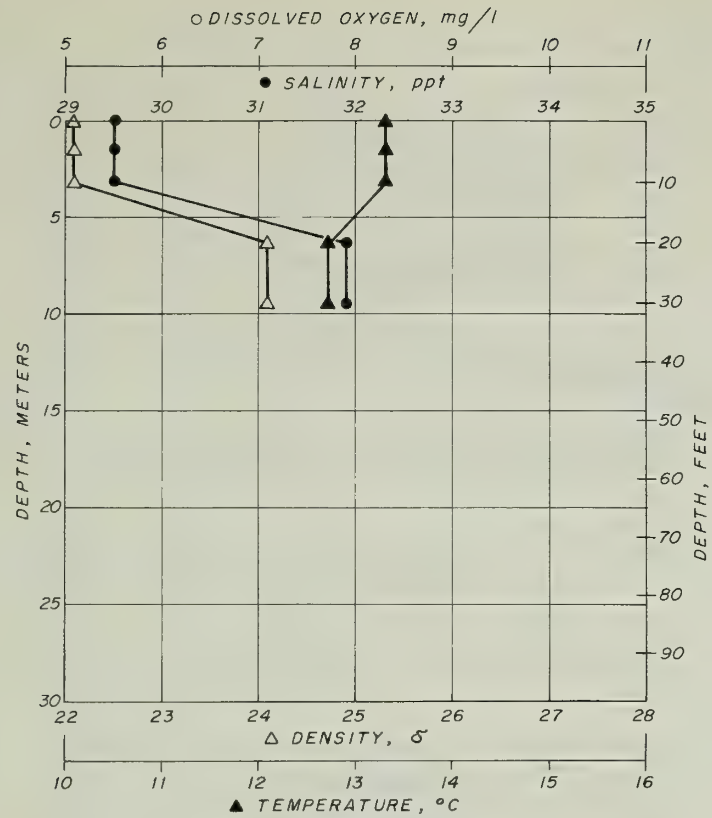
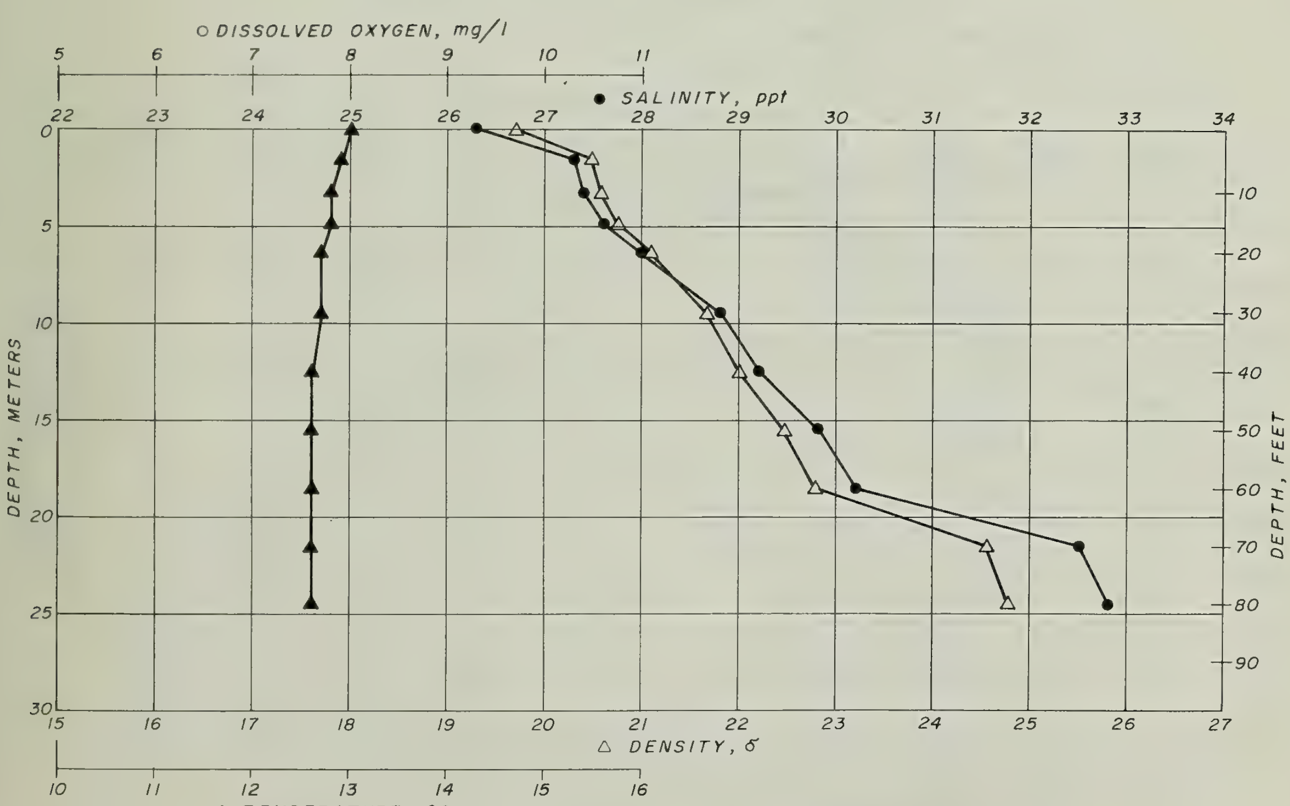
DEPTH, FT 75 REFERENCE FIG. 4-13



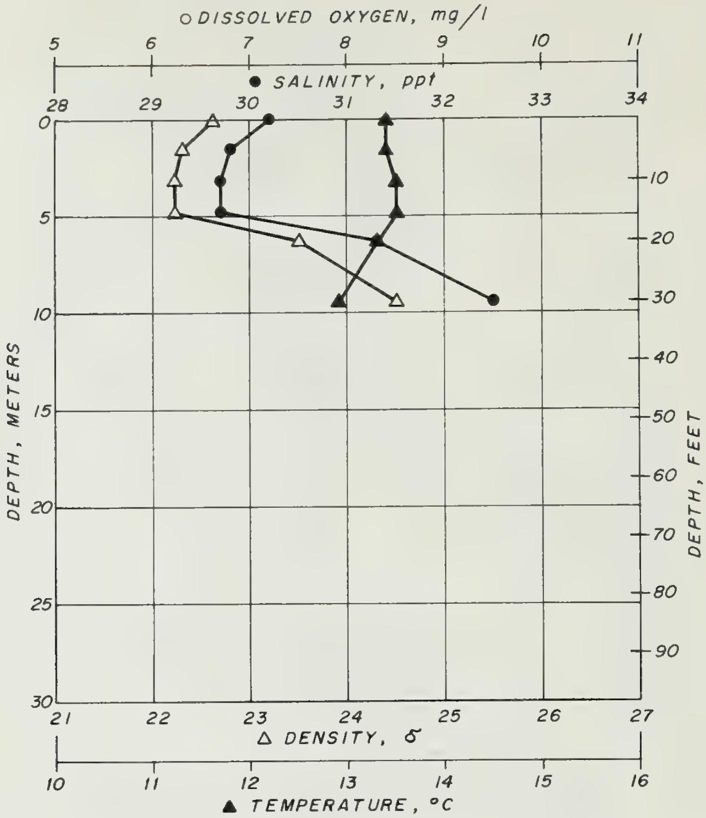
STATION OCEAN DATE 2/24/70 TIME 1446

DEPTH, FT 40 REFERENCE FIG. 4-13

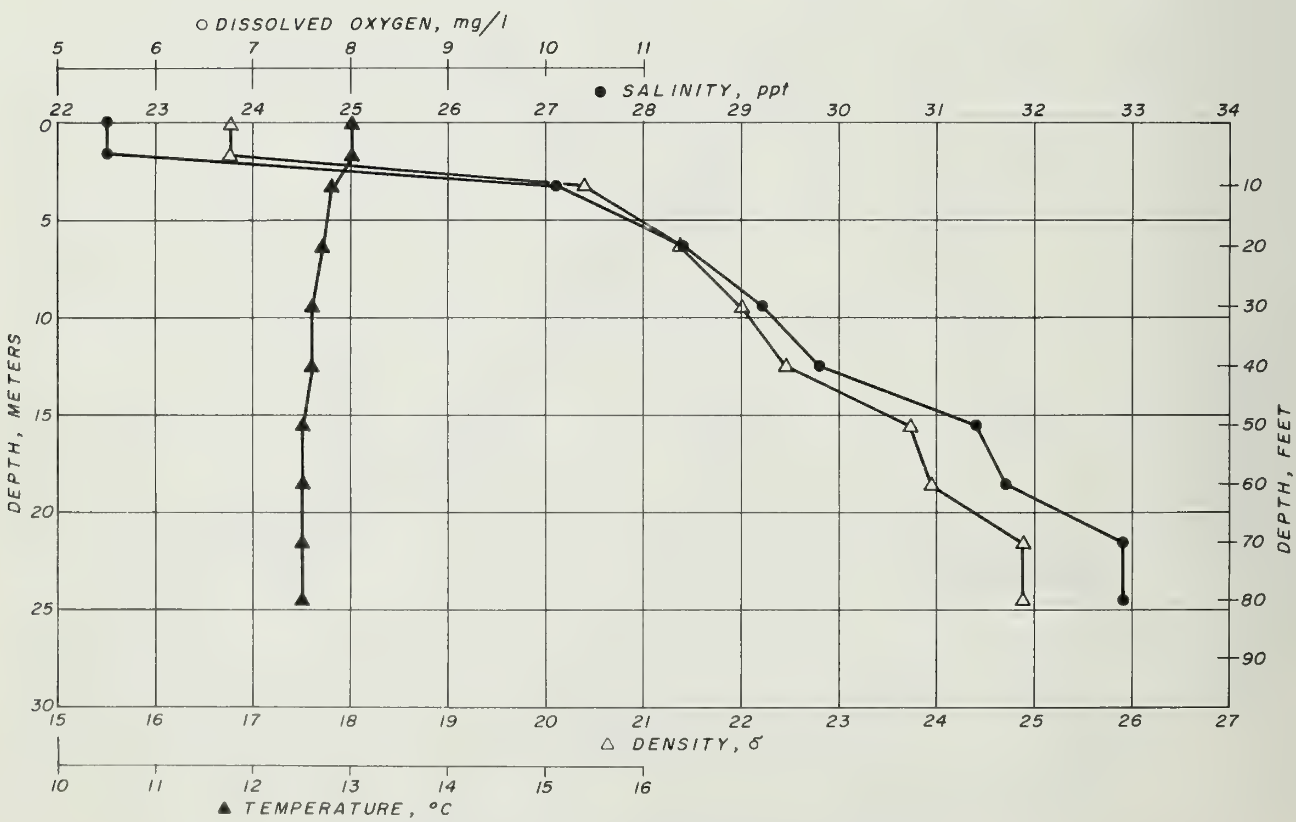


STATION 99 DATE 2/24/70 TIME 1530

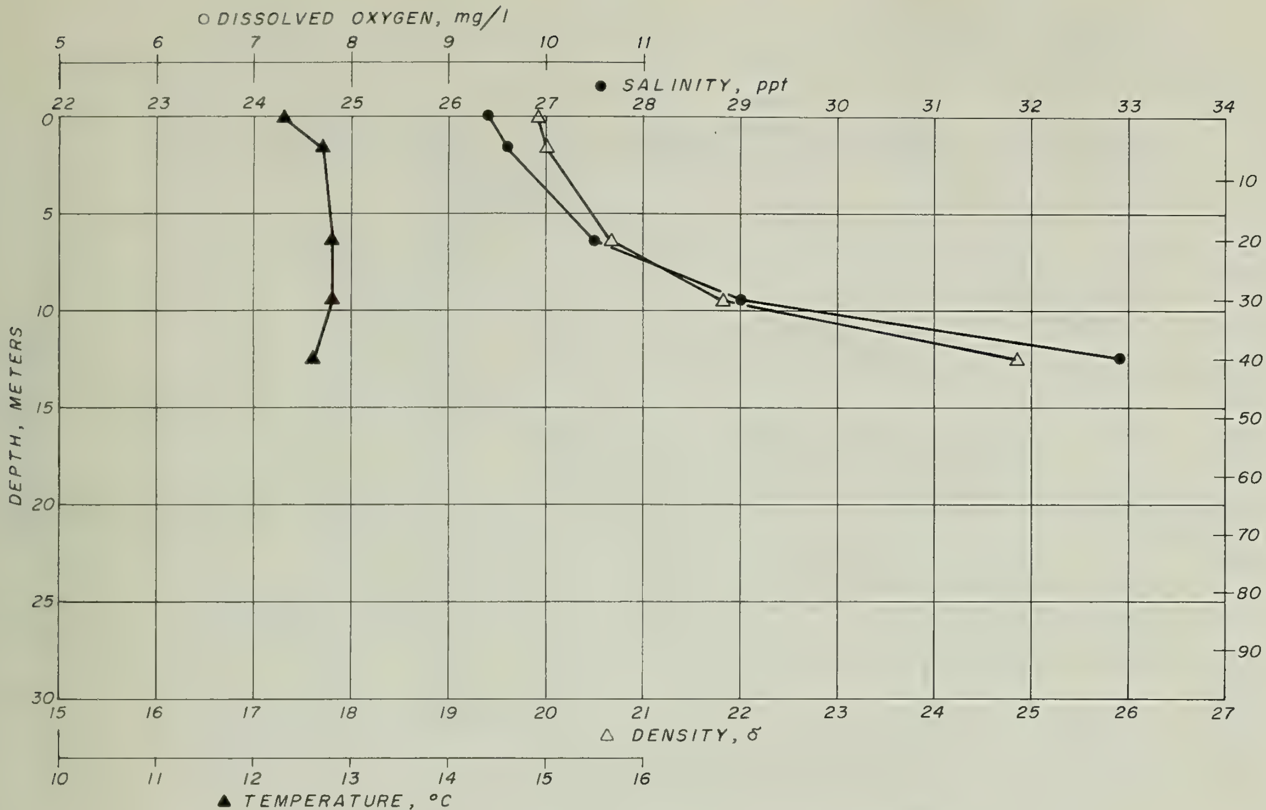
DEPTH, FT 75 REFERENCE FIG. 4-13



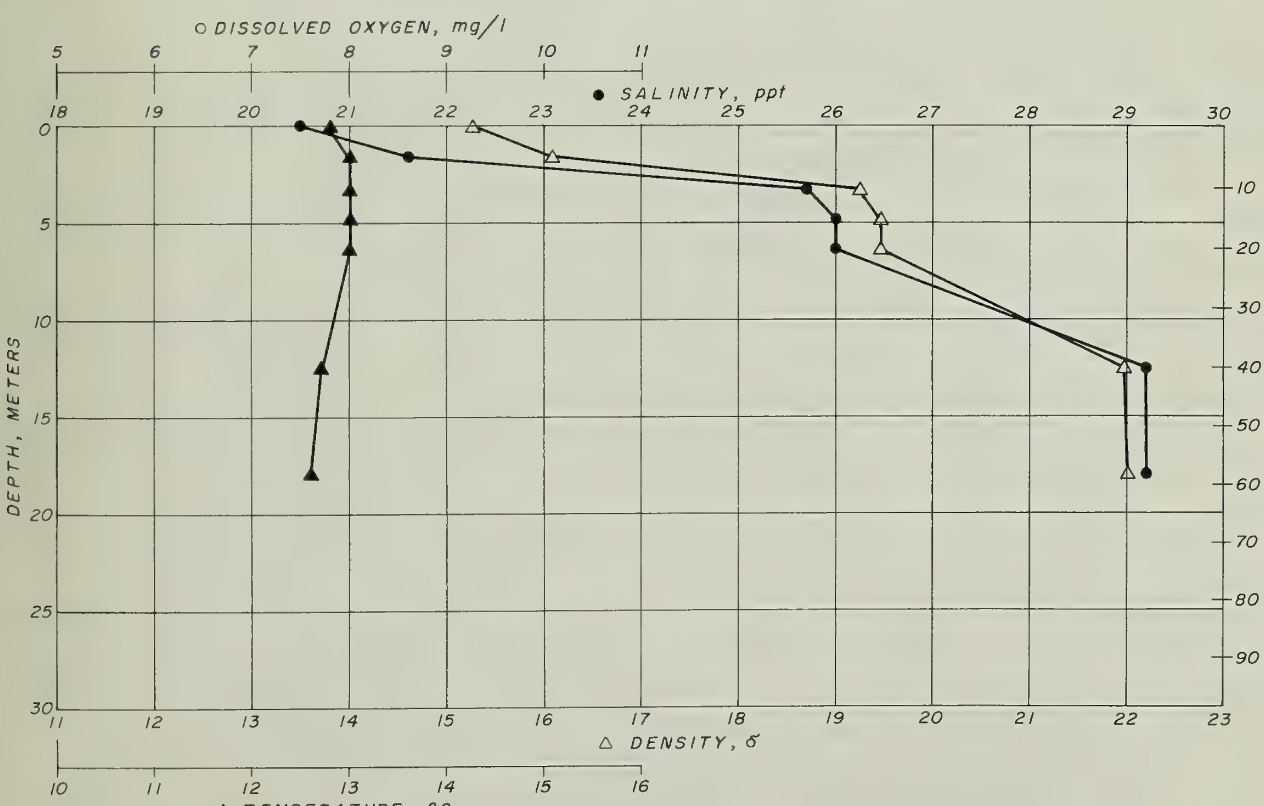
STATION OCEAN DATE 2/24/70 TIME 1608
DEPTH, FT 35 REFERENCE FIG. 4-13



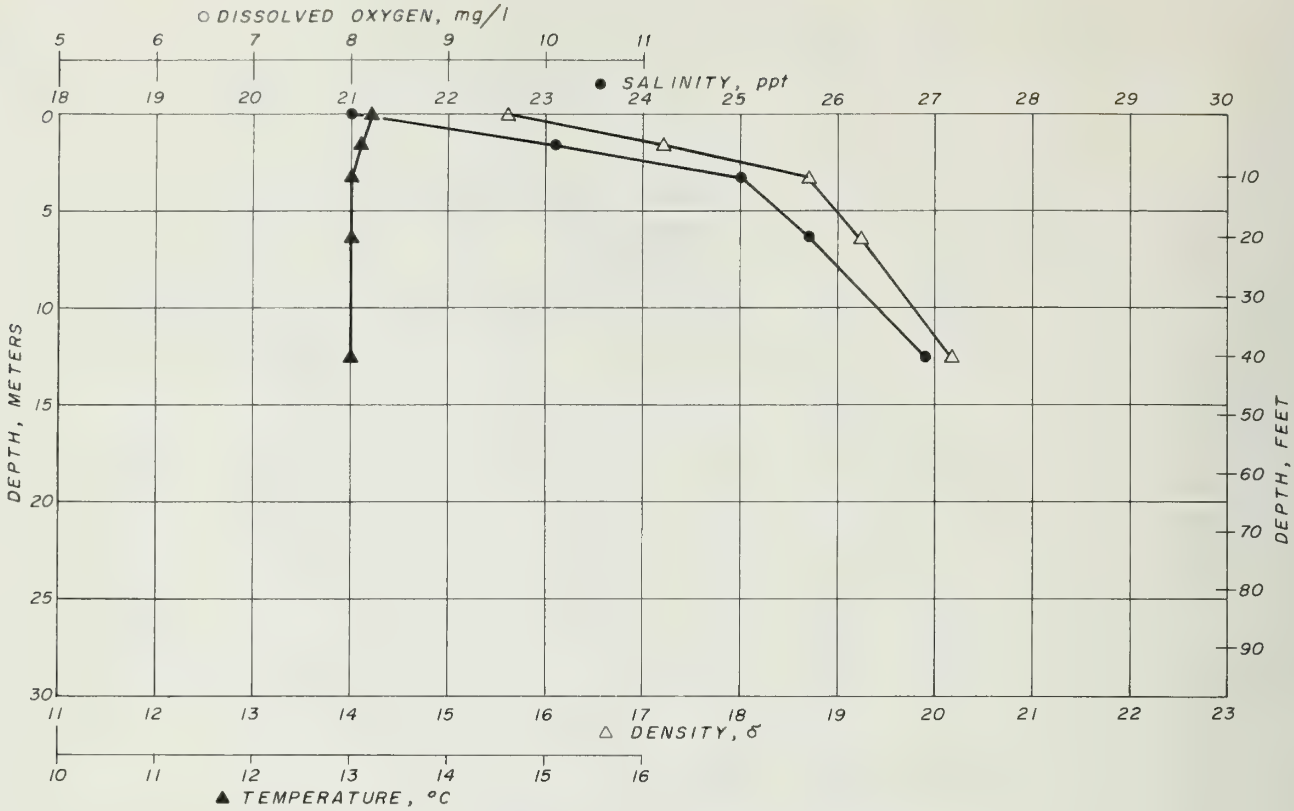
STATION 99 DATE 2/24/70 TIME 1700
DEPTH, FT 75 REFERENCE FIG. 4-13



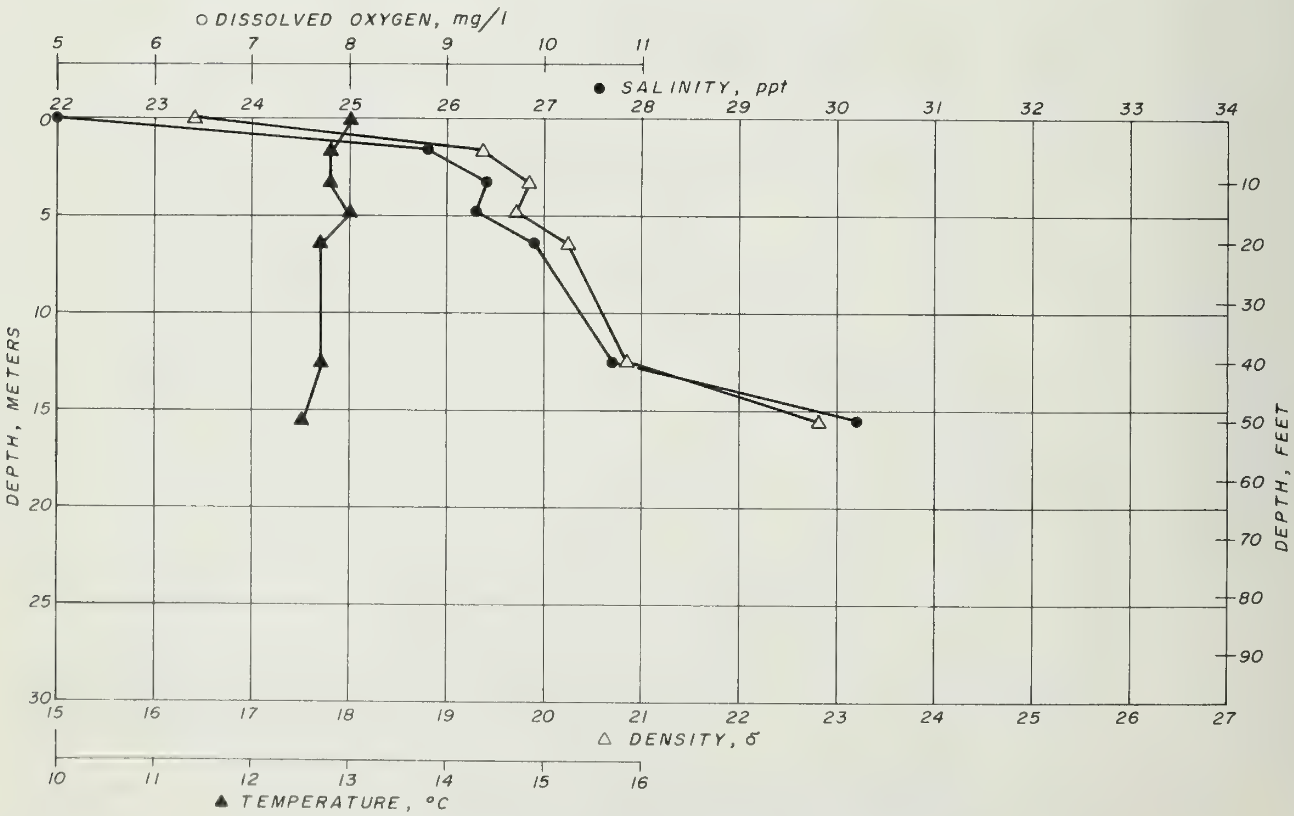
STATION OCEAN DATE 2/25/70 TIME 0450
DEPTH, FT 60 REFERENCE FIG. 4-13



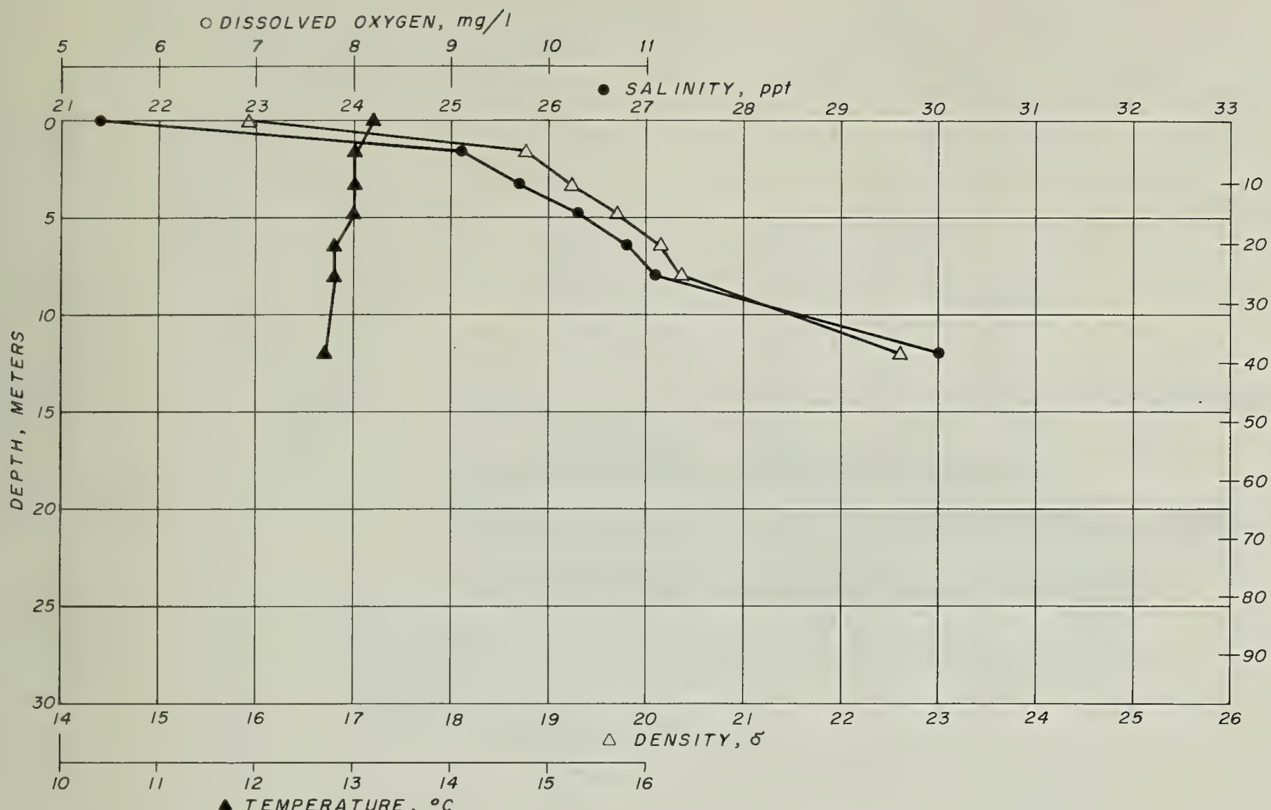
STATION 96 DATE 2/25/70 TIME 0935
DEPTH, FT 60 REFERENCE FIG. 4-13



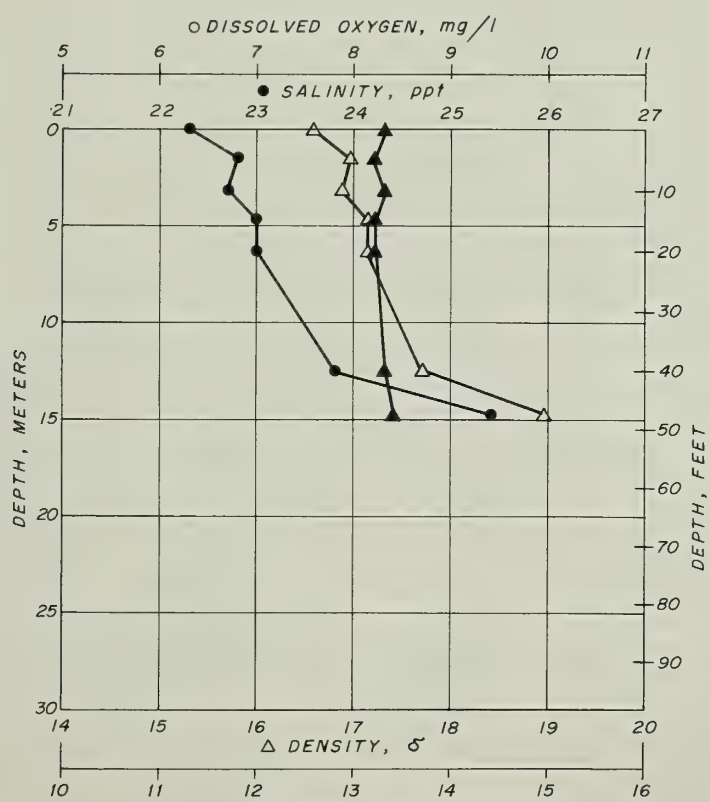
STATION 97 DATE 2/25/70 TIME 1059
DEPTH, FT 40 REFERENCE FIG. 4-13



STATION 95 DATE 2/25/70 TIME 1118
DEPTH, FT 50 REFERENCE FIG. 4-13

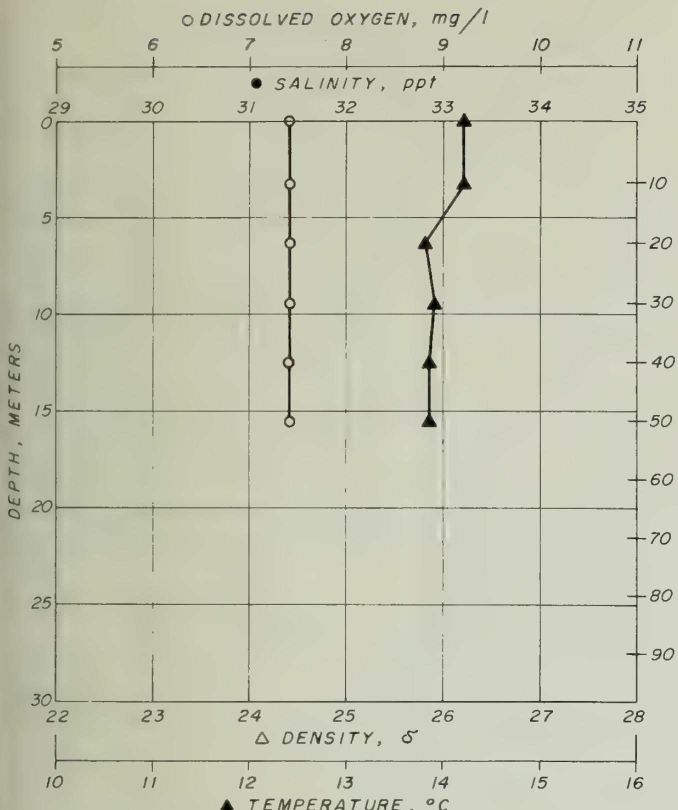


STATION OCEAN DATE 2/25/70 TIME 1135
DEPTH, FT 40 REFERENCE FIG. 4-13

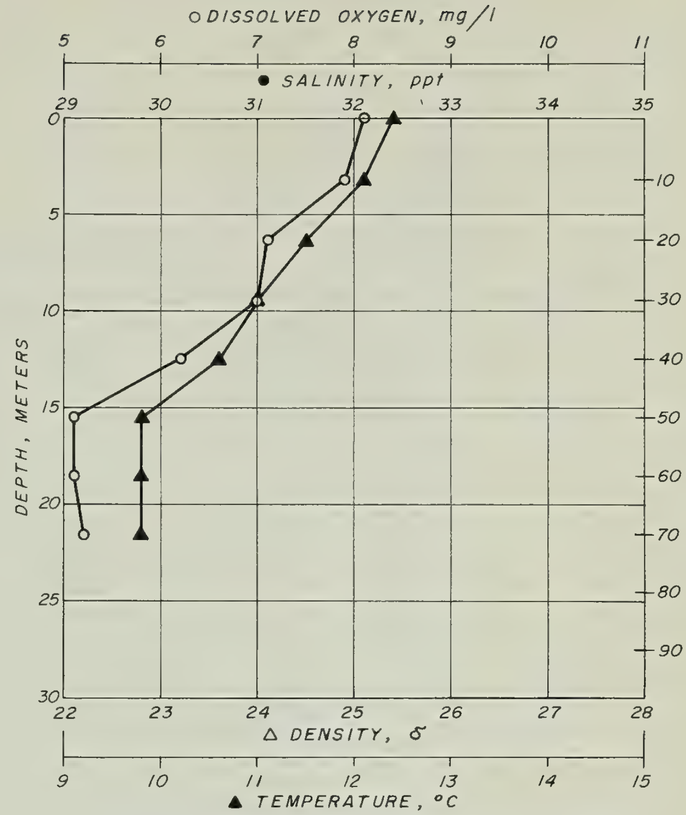


STATION 65 DATE 2/25/70 TIME 1238
DEPTH, FT 120 REFERENCE FIG. 4-13

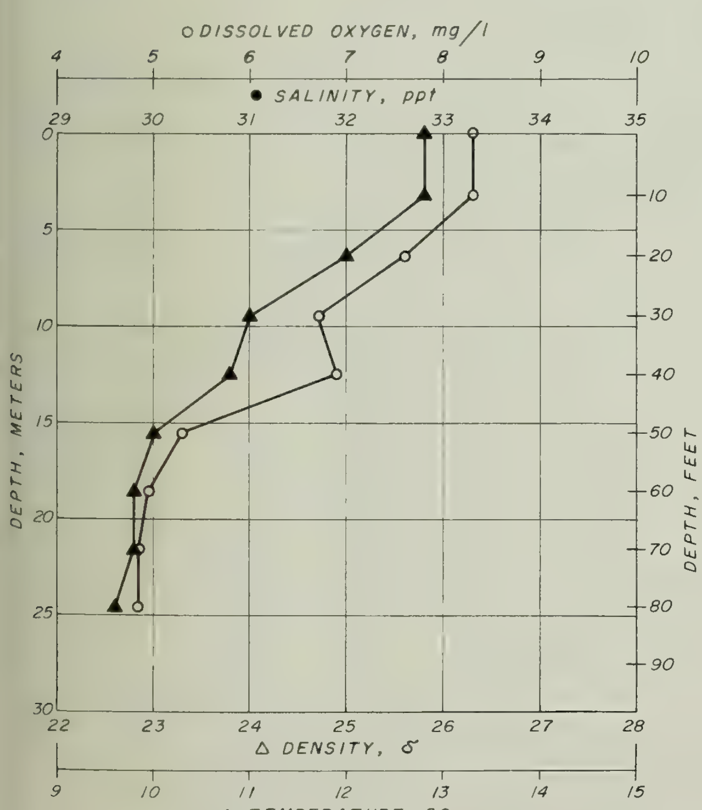
Gulf of the Farallones
Physical - Chemical Characteristics
Summer Upwelling Season



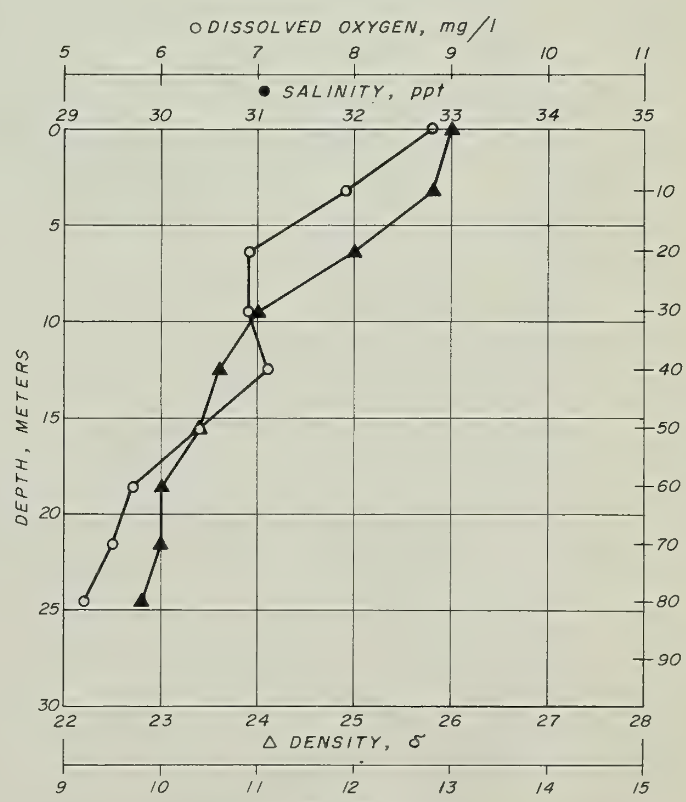
STATION x DATE 6/17/70 TIME 0733
DEPTH, FT 60 REFERENCE FIG. 4-19



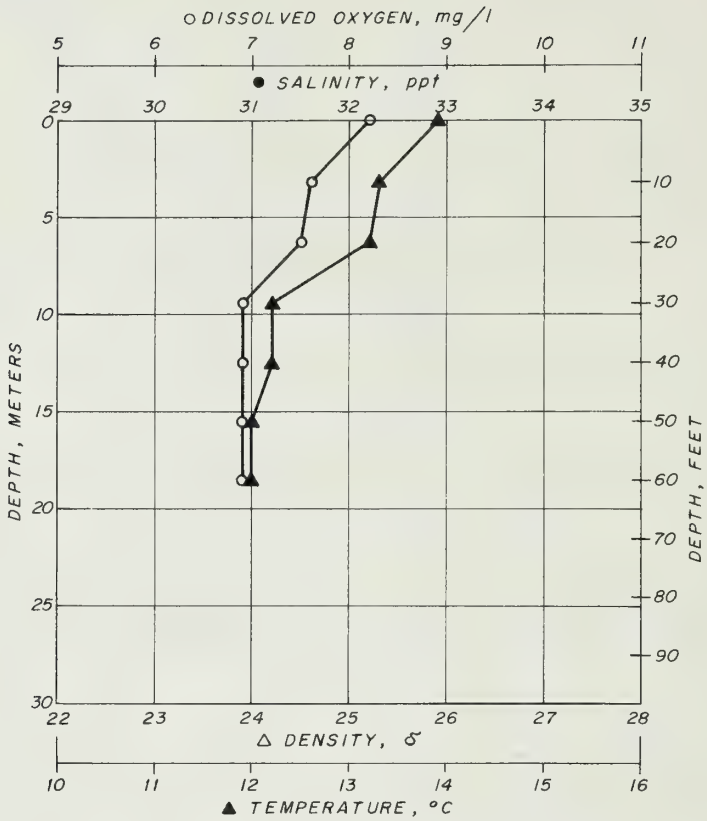
STATION OCEAN DATE 6/17/70 TIME 1121
DEPTH, FT 75 REFERENCE FIG. 4-19



STATION Y DATE 6/17/70 TIME 1258
DEPTH, FT 90 REFERENCE FIG. 4-19

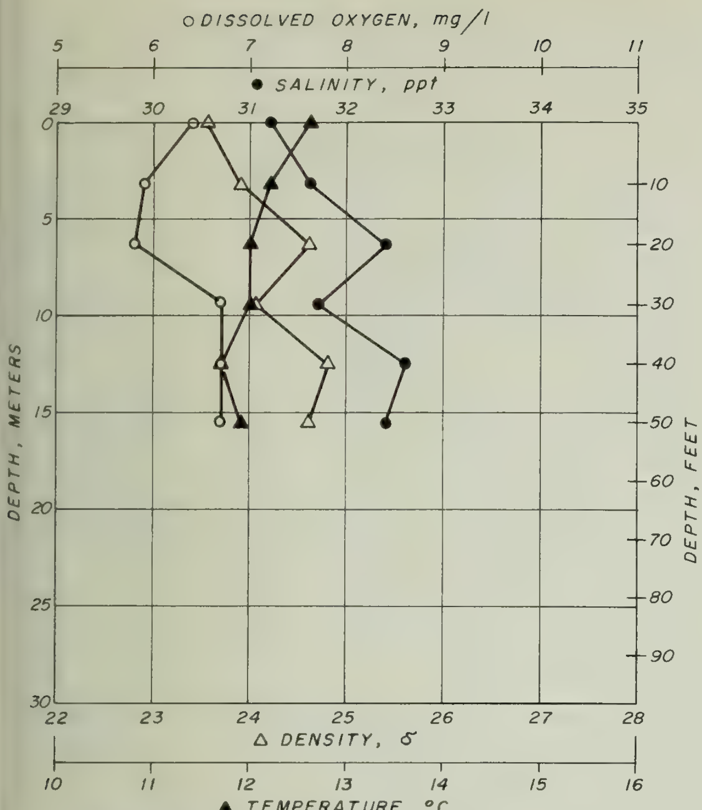


STATION OCEAN DATE 6/17/70 TIME 1444
DEPTH, FT 90 REFERENCE FIG. 4-19

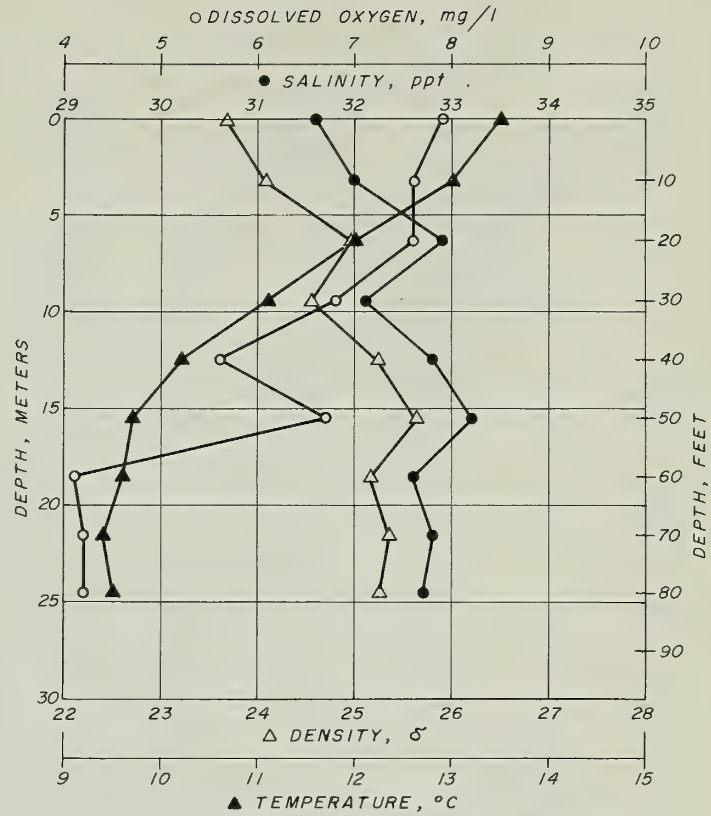


STATION _OCEAN_ DATE _6/17/70_ TIME _1911_

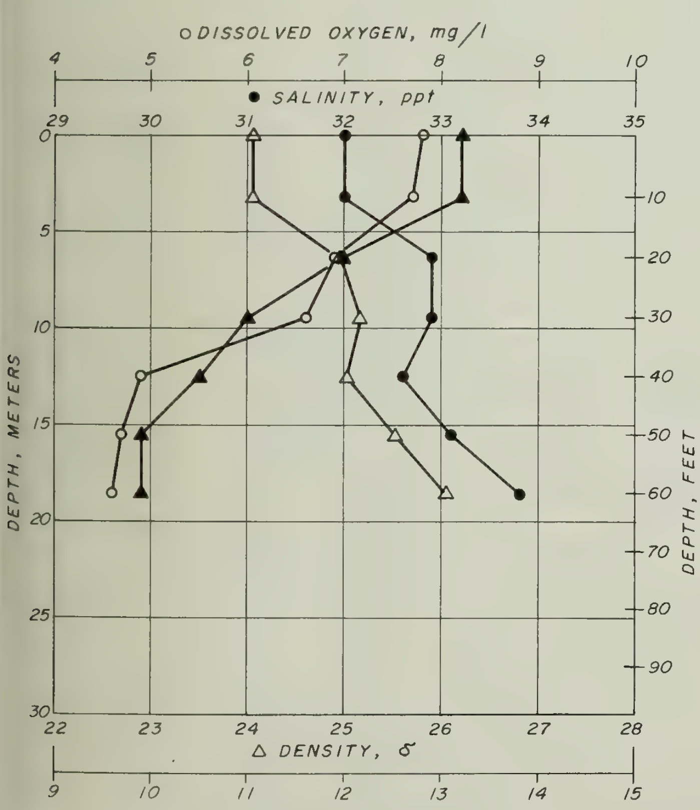
DEPTH, FT _80_ REFERENCE FIG. _4-19_



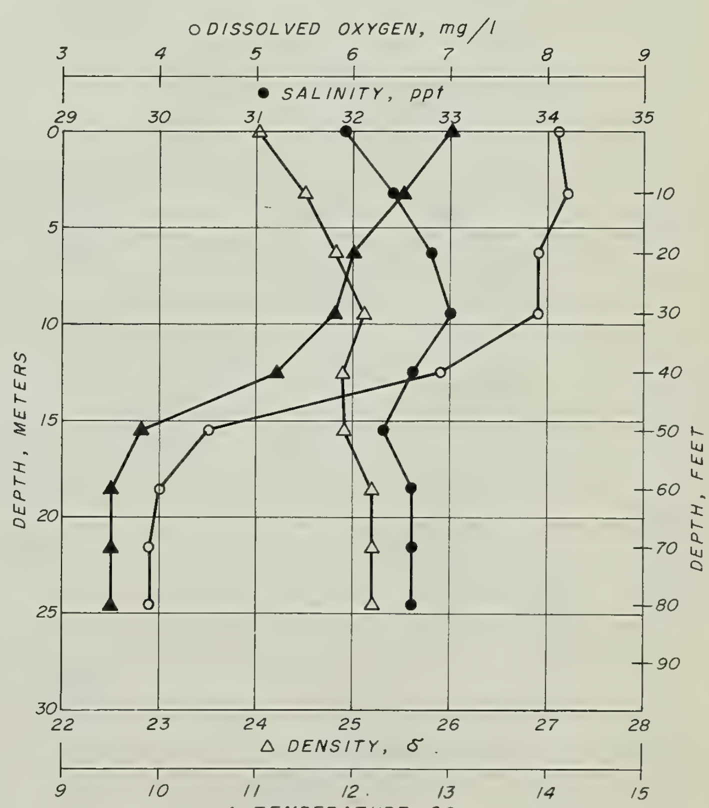
STATION X DATE 6/18/70 TIME 1045
DEPTH, FT 60 REFERENCE FIG. 4-20



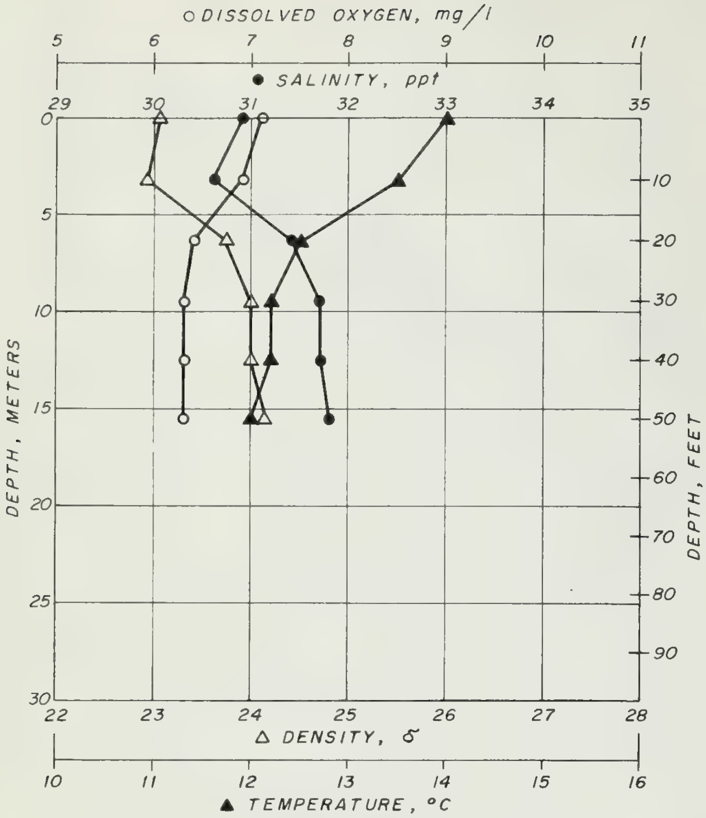
STATION Y DATE 6/18/70 TIME 1337
DEPTH, FT 90 REFERENCE FIG. 4-20



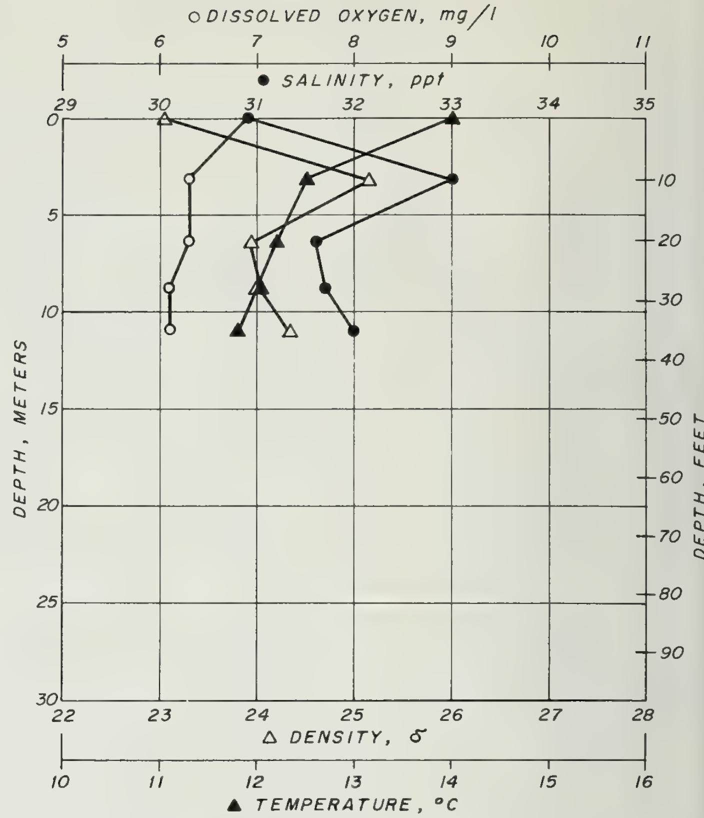
STATION VICINITY Y DATE 6/18/70 TIME 1438
DEPTH, FT 70 REFERENCE FIG. 4-20



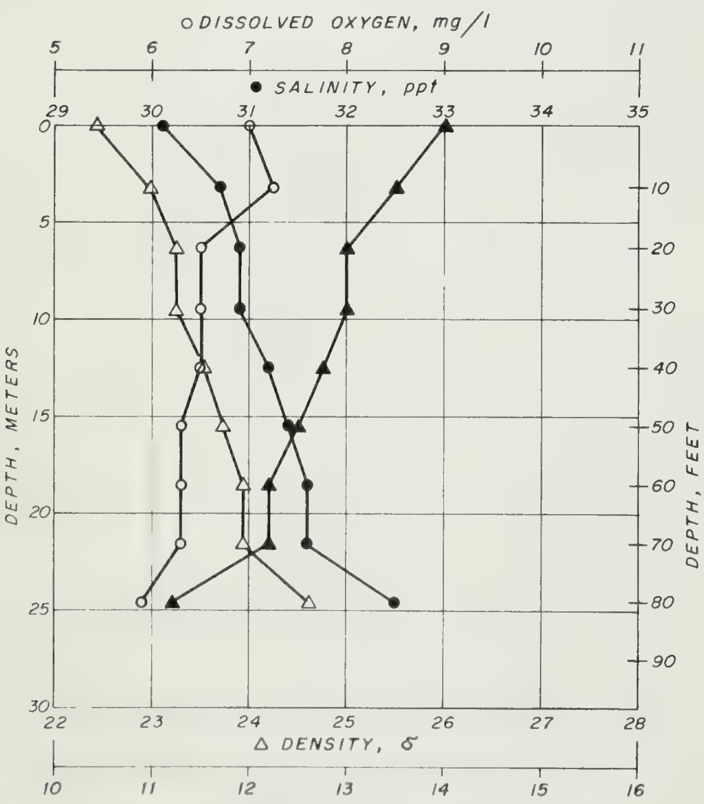
STATION VICINTY Y DATE 6/18/70 TIME 1533
DEPTH, FT 90 REFERENCE FIG. 4-20



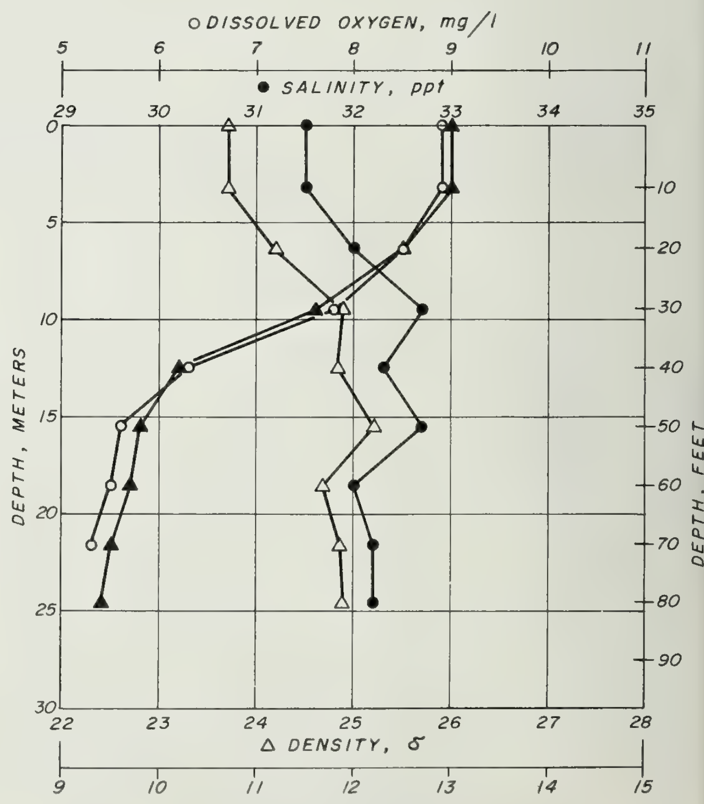
STATION X DATE 6/18/70 TIME 1700
DEPTH, FT 60 REFERENCE FIG. 4-20



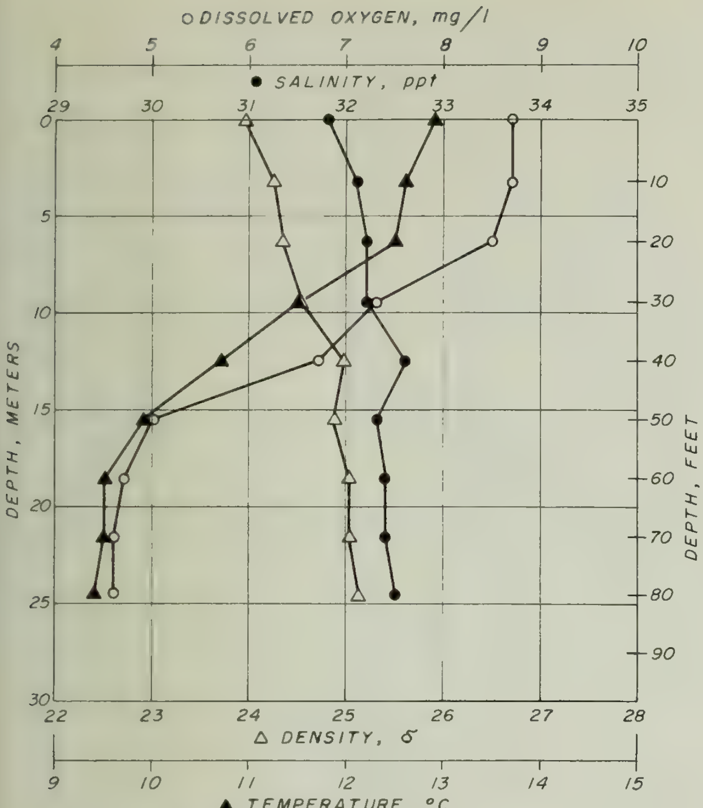
STATION VICINTY X DATE 6/18/70 TIME 1809
DEPTH, FT 40 REFERENCE FIG. 4-20



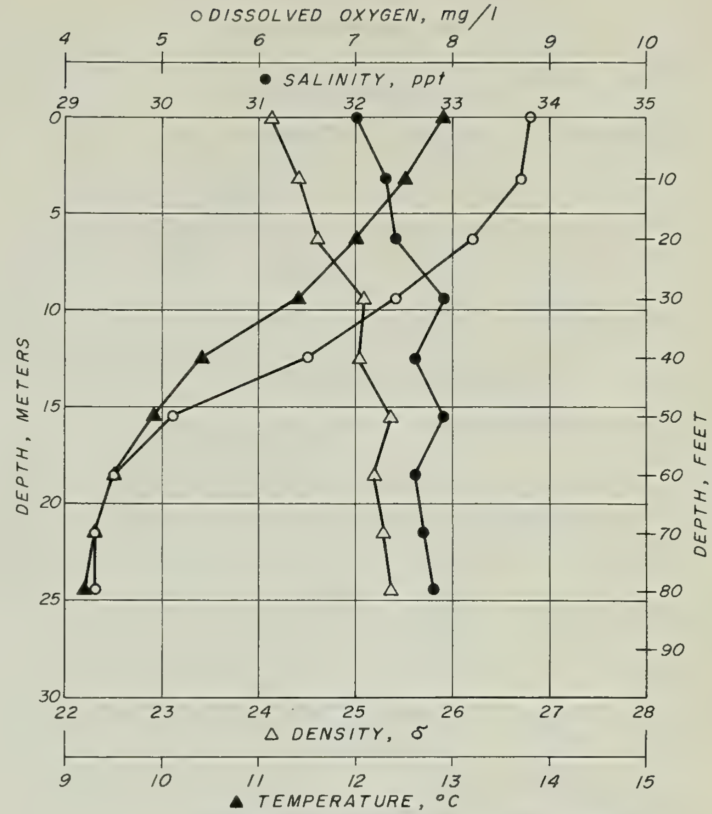
STATION VICINITY X DATE 6/18/70 TIME 1912
DEPTH, FT 90 REFERENCE FIG. 4-20



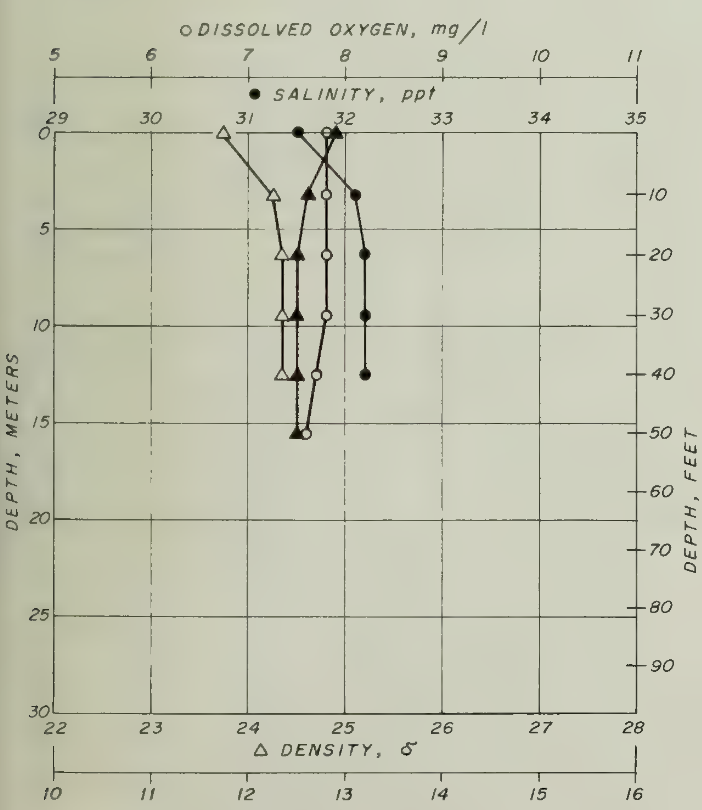
STATION Y DATE 6/18/70 TIME 2115
DEPTH, FT 90 REFERENCE FIG. 4-20



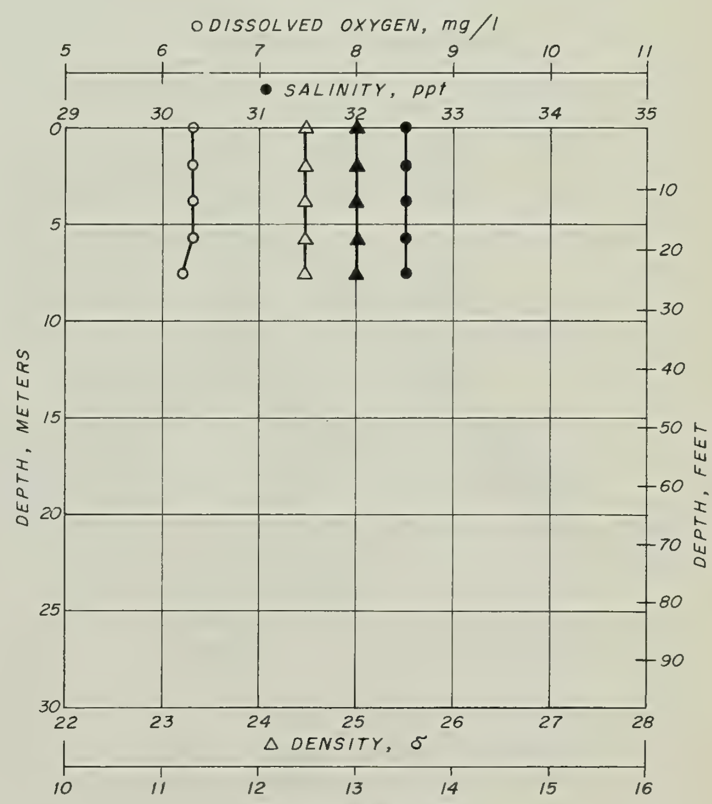
STATION VICINITY Y DATE 6/18/70 TIME 2258
DEPTH, FT 85 REFERENCE FIG. 4-20



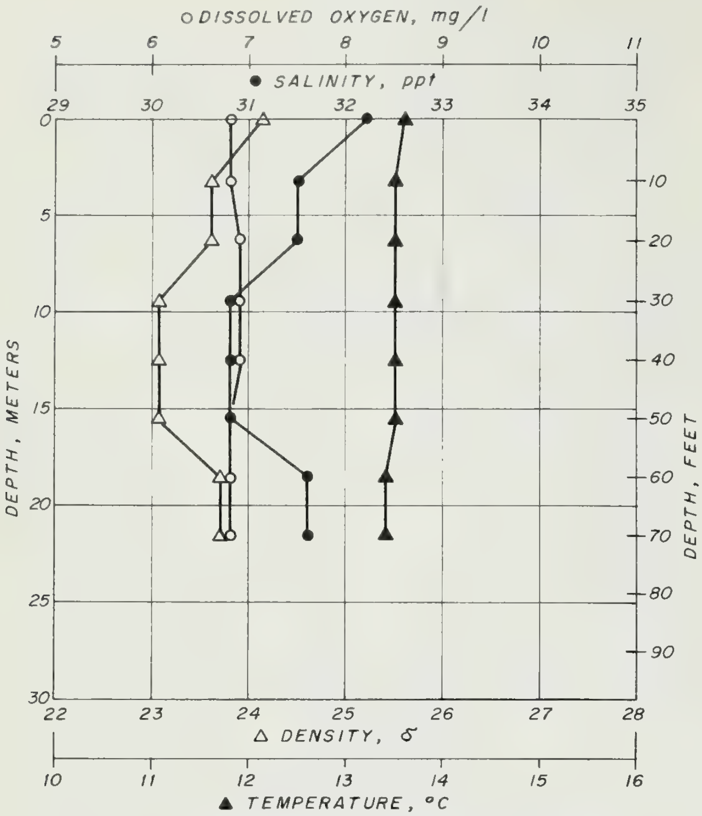
STATION VICINITY Y DATE 6/19/70 TIME 0003
DEPTH, FT 90 REFERENCE FIG. 4-20



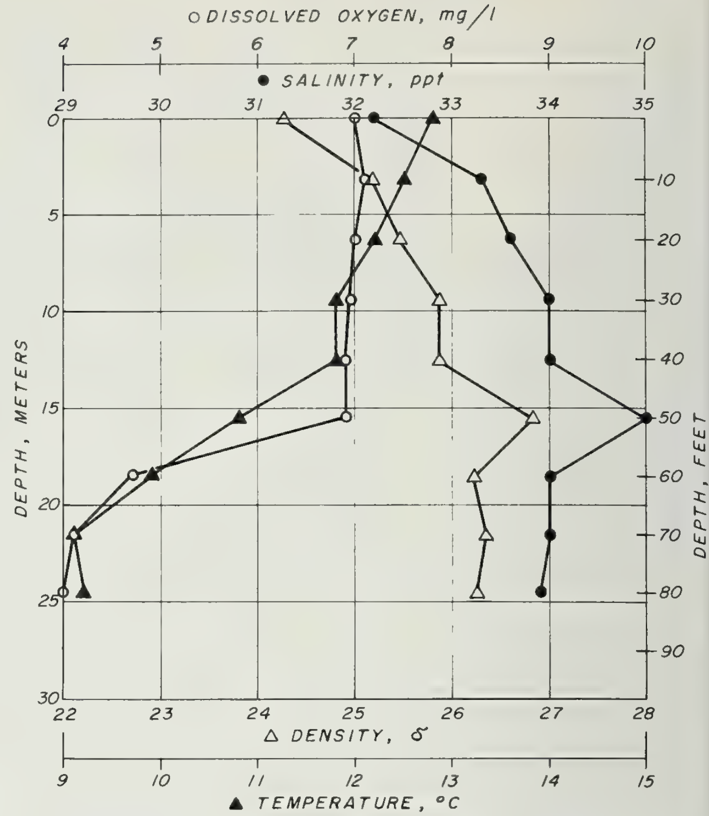
STATION X DATE 6/19/70 TIME 0233
DEPTH, FT 60 REFERENCE FIG. 4-20



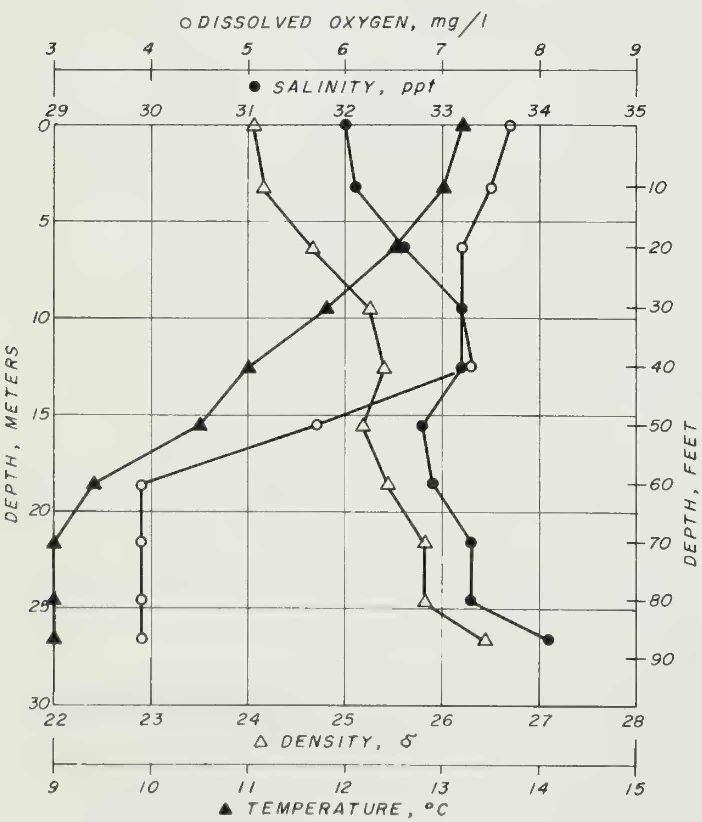
STATION VICINITY X DATE 6/19/70 TIME 0423
DEPTH, FT 30 REFERENCE FIG. 4-20



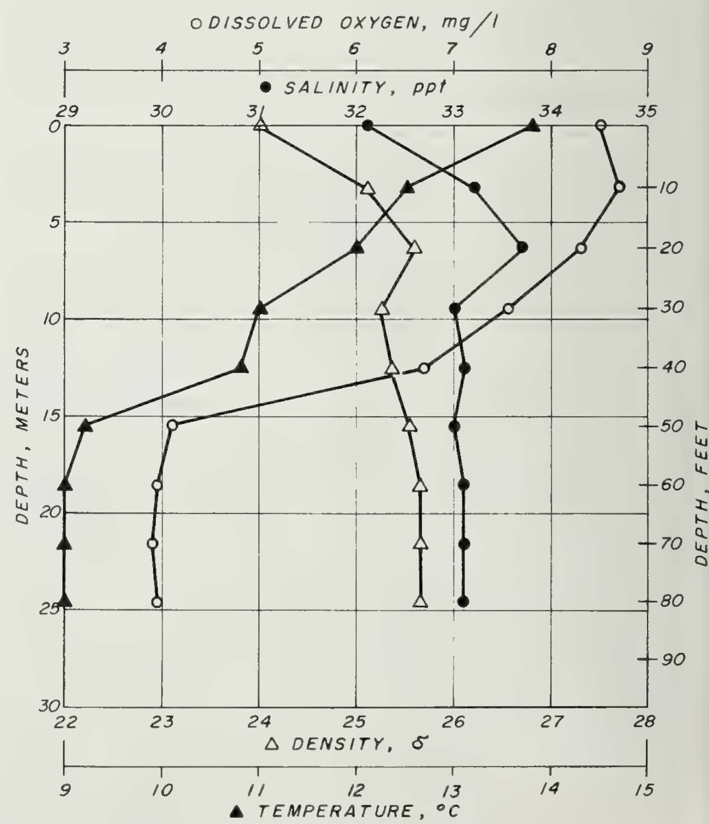
STATION VICINTY X DATE 6/19/70 TIME 0535
DEPTH, FT 80 REFERENCE FIG. 4-20



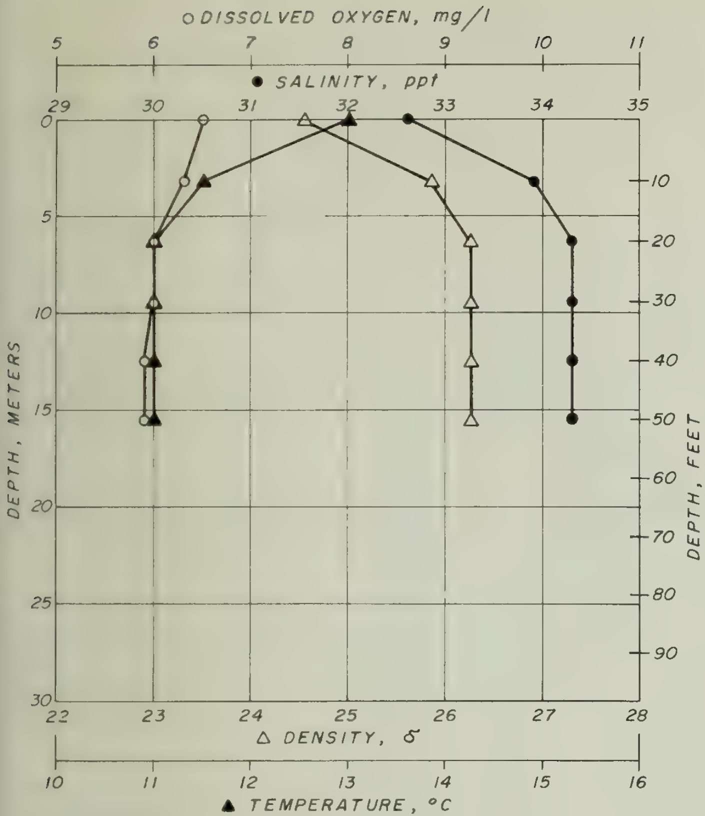
STATION Y DATE 6/19/70 TIME 0727
DEPTH, FT 90 REFERENCE FIG. 4-20



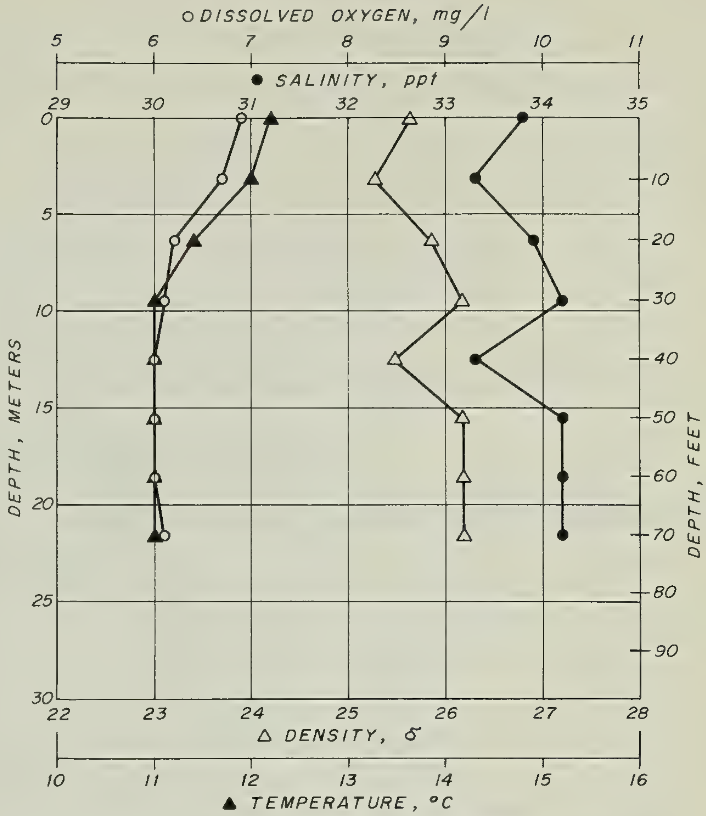
STATION VICINITY Y DATE 6/19/70 TIME 1017
DEPTH, FT 90 REFERENCE FIG. 4-20



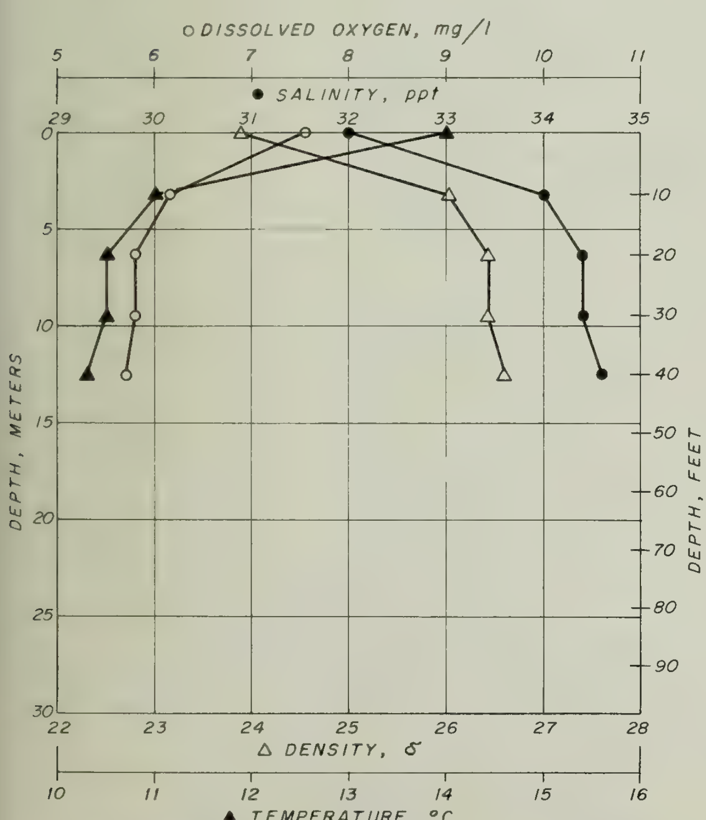
STATION VICINITY Y DATE 6/19/70 TIME 1050
DEPTH, FT 90 REFERENCE FIG. 4-20



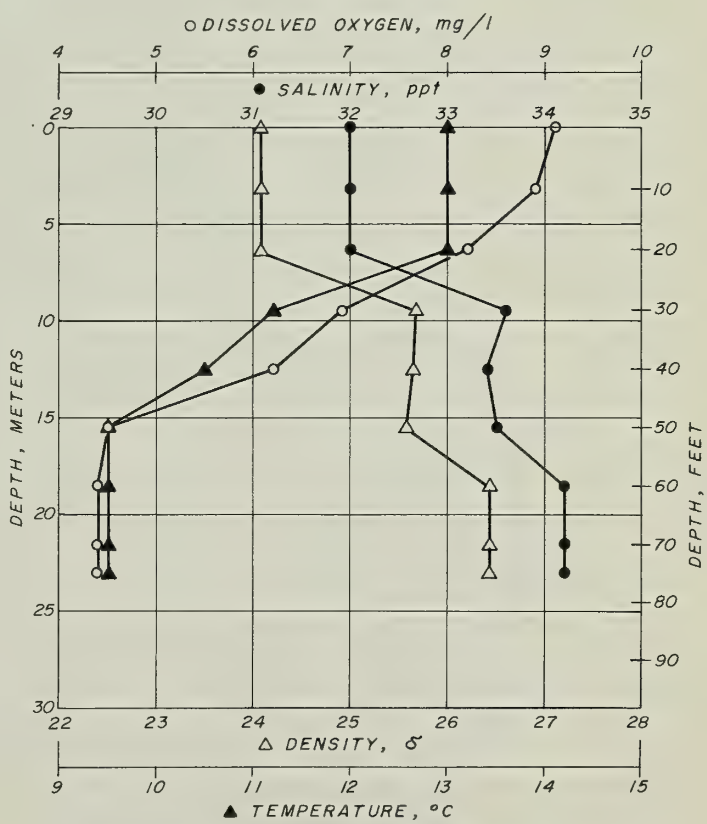
STATION X DATE 6/19/70 TIME 1154
DEPTH, FT 60 REFERENCE FIG. 4-20



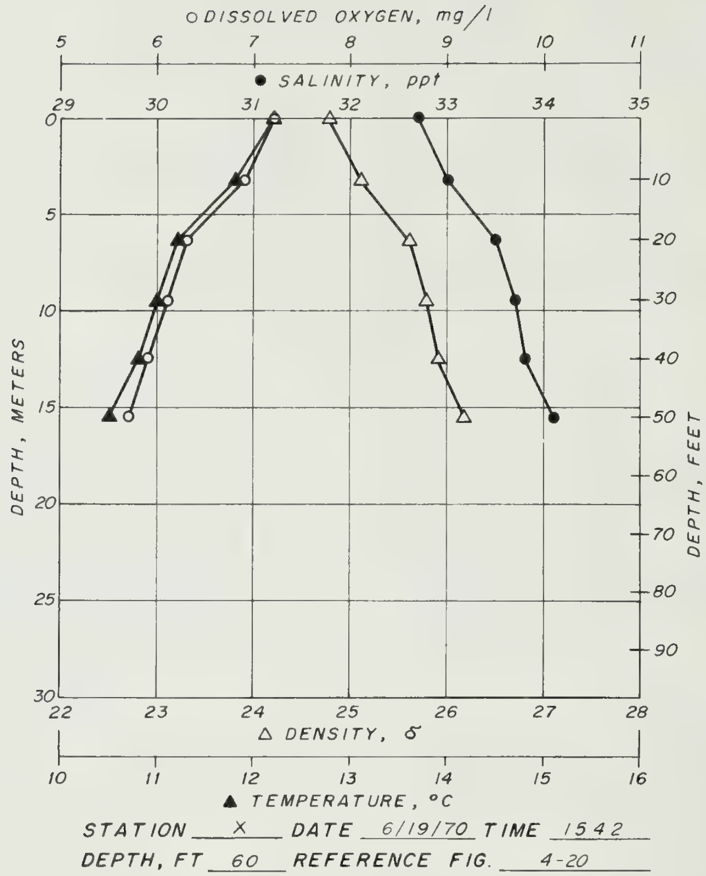
STATION VICINITY X DATE 6/19/70 TIME 1241
DEPTH, FT 80 REFERENCE FIG. 4-20



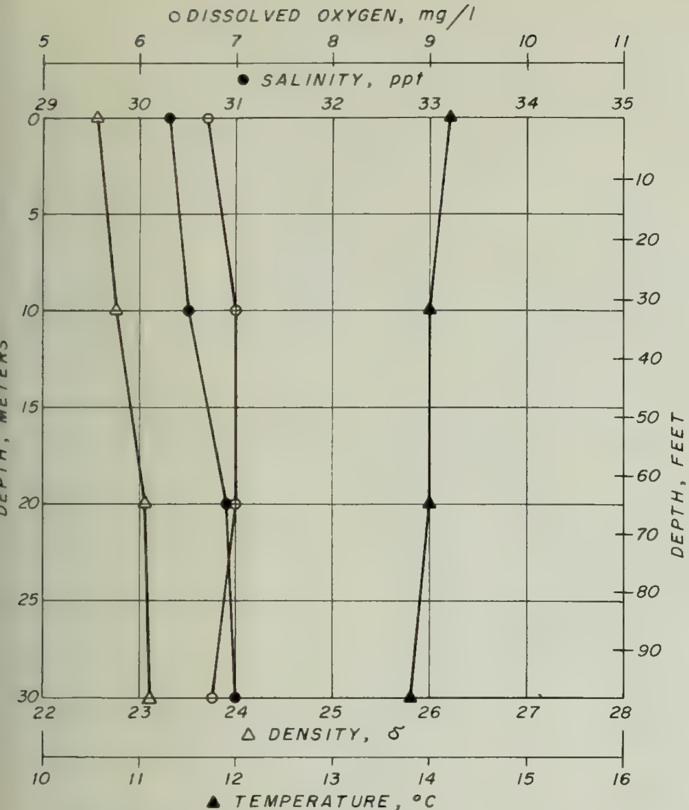
STATION VICINITY X DATE 6/19/70 TIME 1318
DEPTH, FT 50 REFERENCE FIG. 4-20



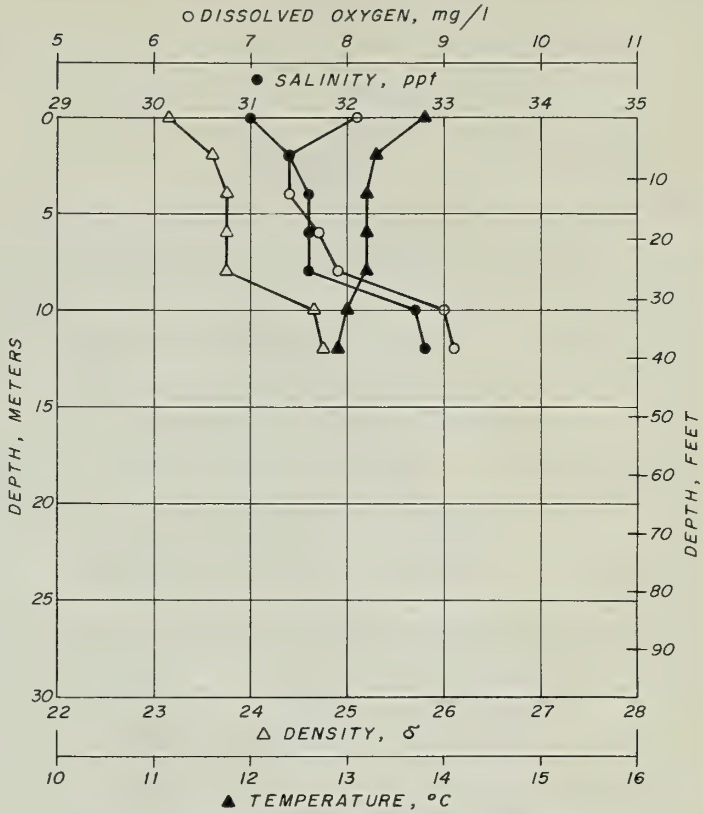
STATION Y DATE 6/19/70 TIME 1430
DEPTH, FT 85 REFERENCE FIG. 4-20


○ DISSOLVED OXYGEN, mg/l
5 6 7 8 9 10 11
● SALINITY, ppt
29 30 31 32 33 34 35
DEPTH, METERS
0 5 10 15 20 25 30
DEPTH, FEET
10 20 30 40 50 60 70 80 90
22 23 24 25 26 27 28
△ DENSITY, σ
10 11 12 13 14 15 16
▲ TEMPERATURE, °C
STATION X DATE 6/19/70 TIME 1542
DEPTH, FT 60 REFERENCE FIG. 4-20

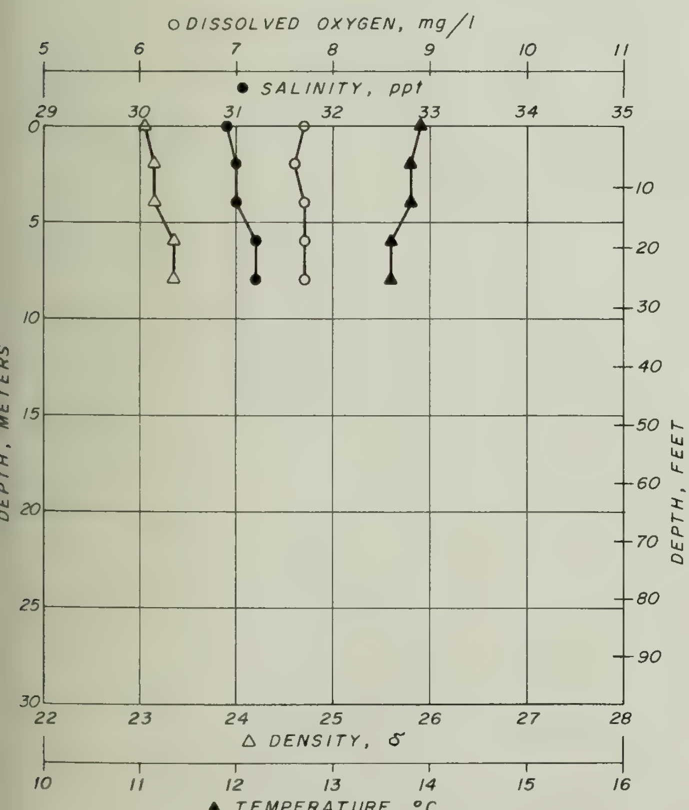
Gulf of the Farallones
Physical - Chemical Characteristics
Fall Season



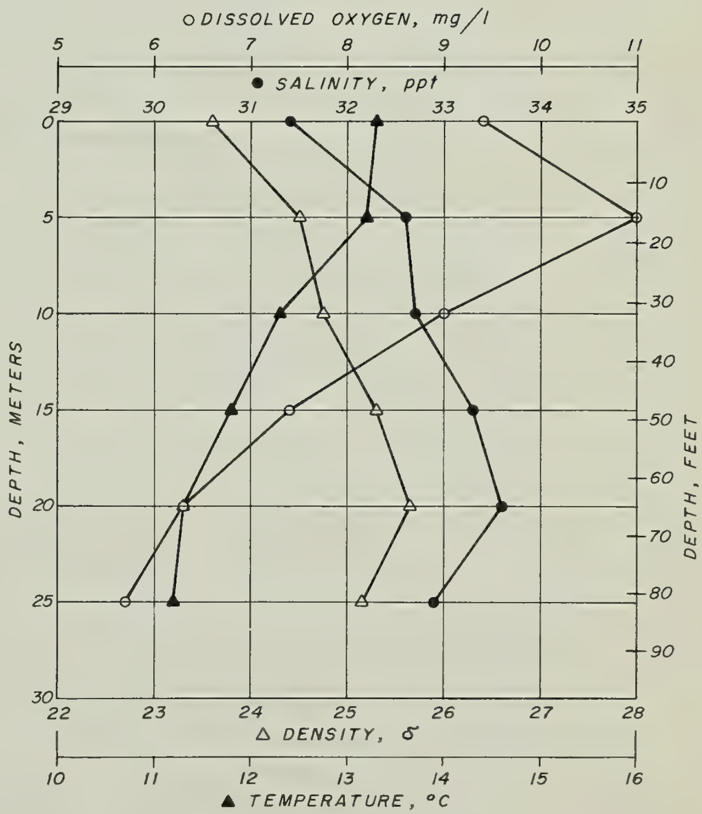
STATION OCEAN DATE 10/5/70 TIME 1235
DEPTH, FT 300 REFERENCE FIG. 4-27



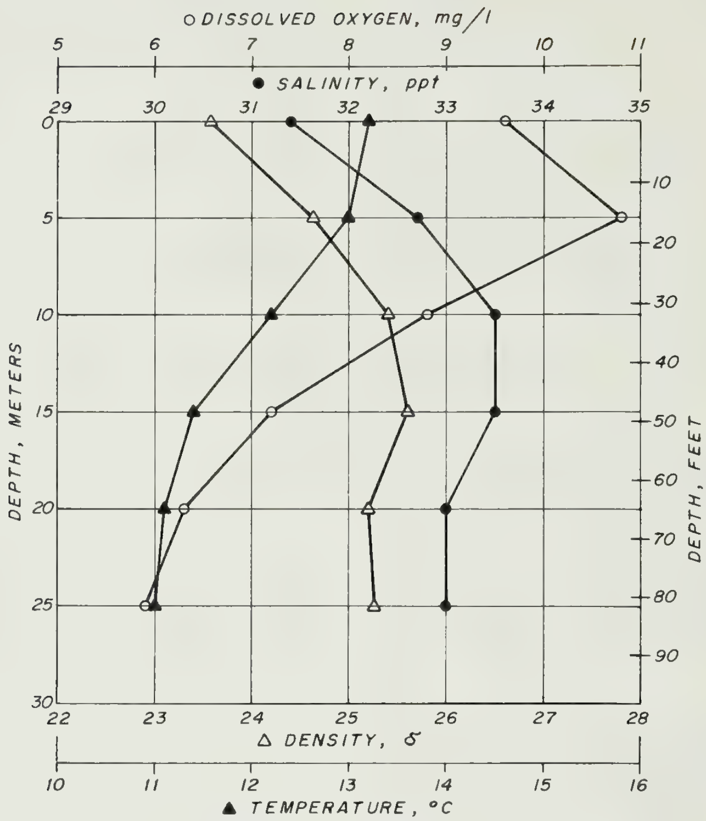
STATION OCEAN DATE 10/5/70 TIME 1440
DEPTH, FT 40 REFERENCE FIG. 4-27



STATION OCEAN DATE 10/5/70 TIME 1536
DEPTH, FT 25 REFERENCE FIG. 4-27

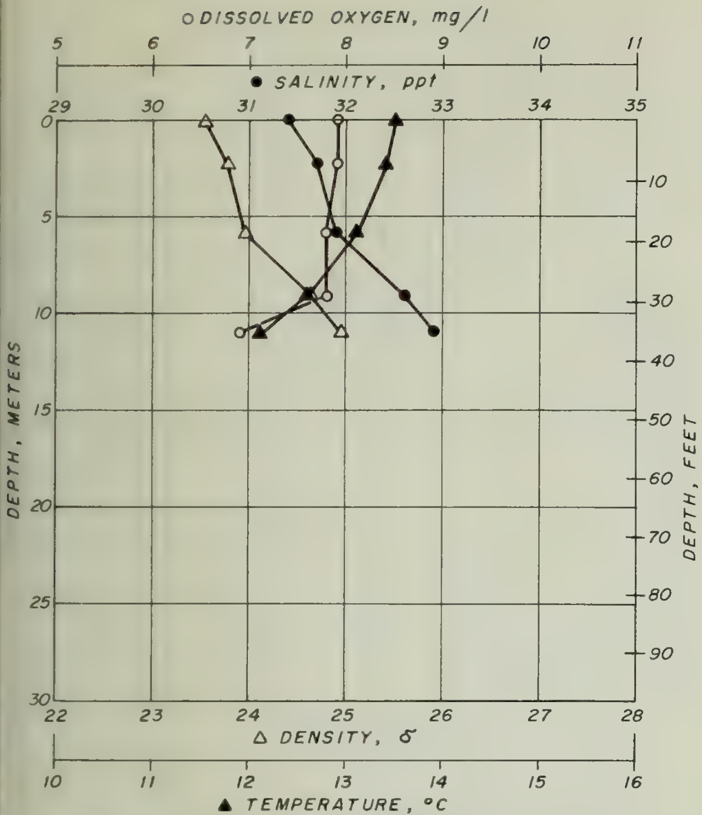


STATION VICINITY B DATE 10/5/70 TIME 1721
DEPTH, FT 90 REFERENCE FIG. 4-27

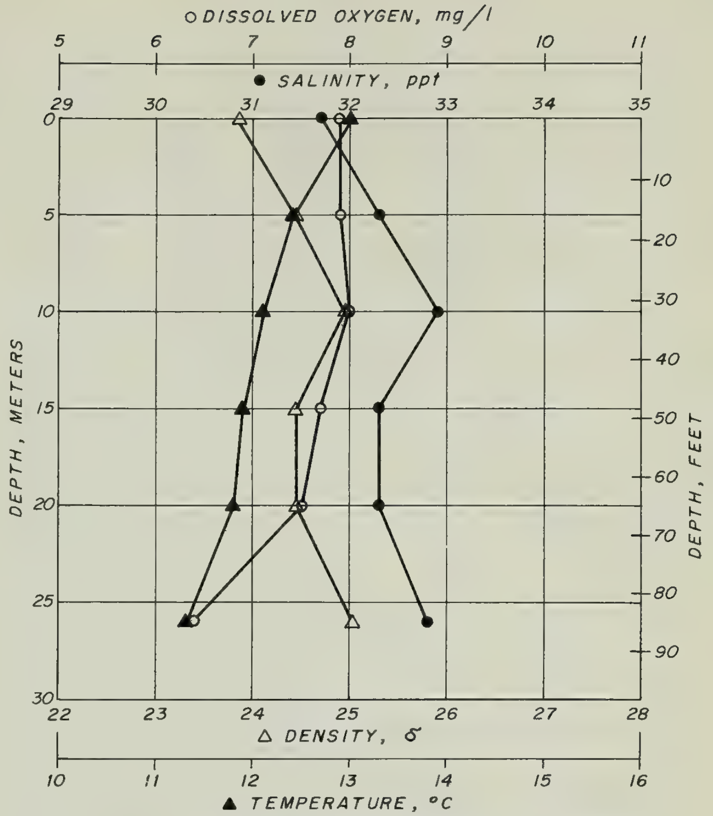


STATION VICINITY B DATE 10/5/70 TIME 1810

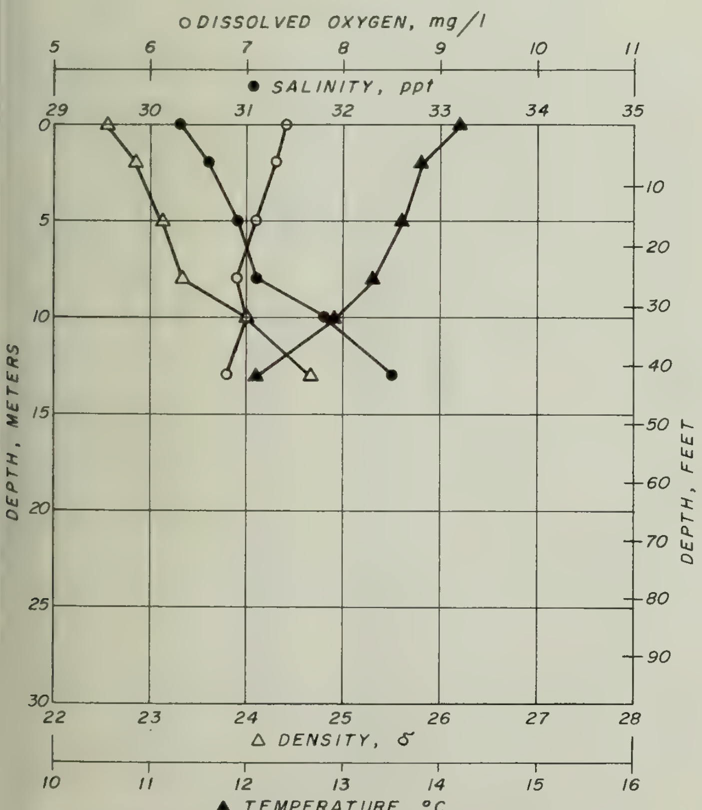
DEPTH, FT 90 REFERENCE FIG. 4-27



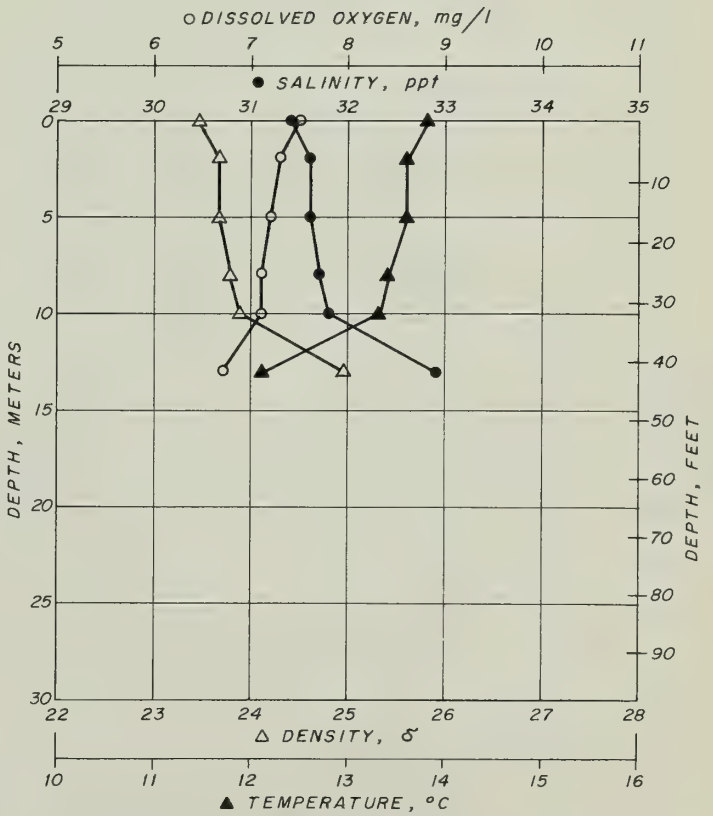
STATION A DATE 10/7/70 TIME 0845
DEPTH, FT 45 REFERENCE FIG. 4-27



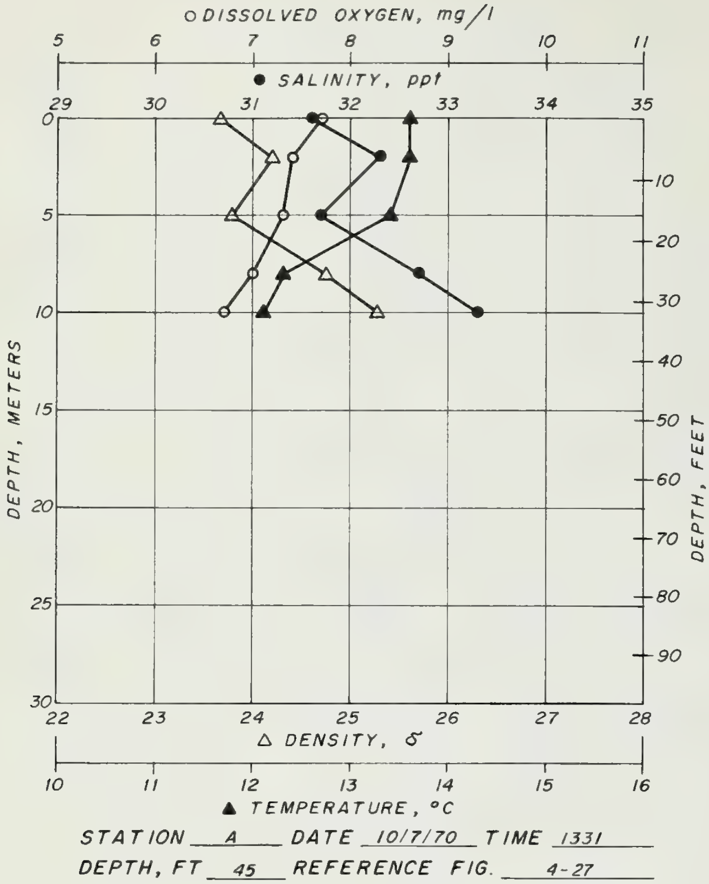
STATION B DATE 10/7/70 TIME 0955
DEPTH, FT 90 REFERENCE FIG. 4-27

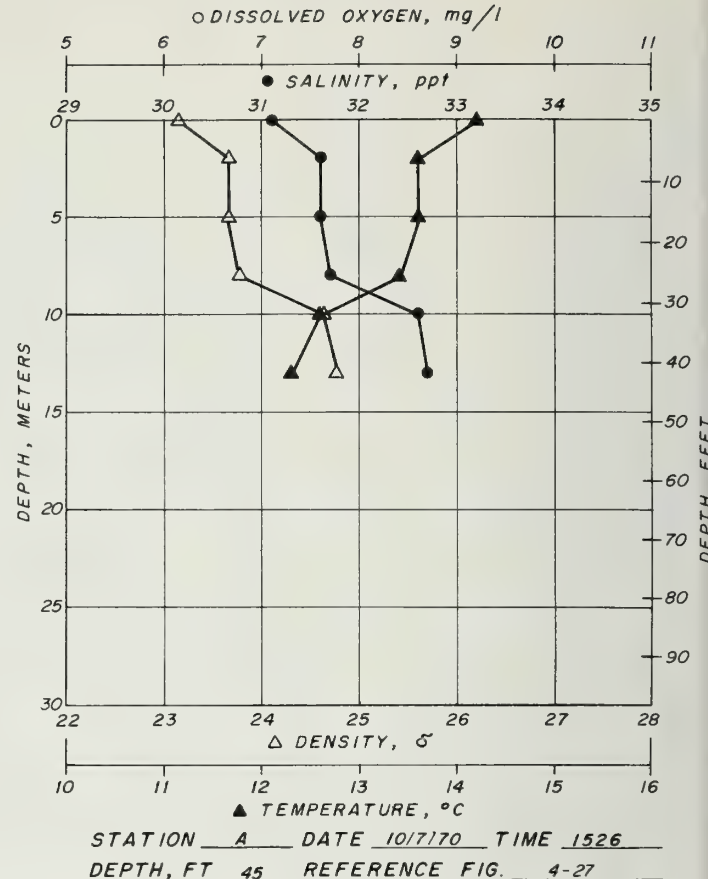


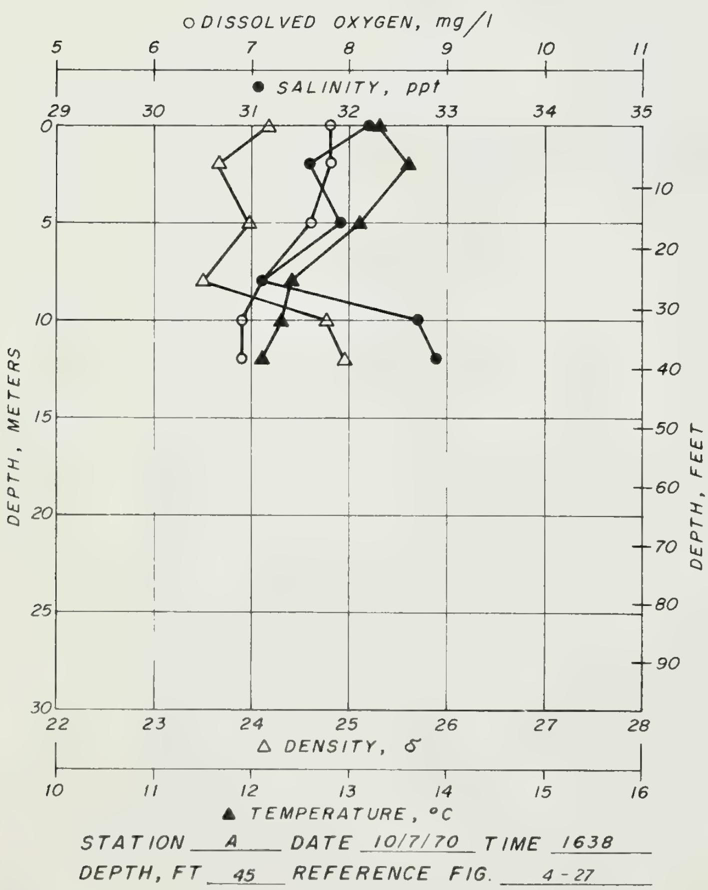
STATION A DATE 10/7/70 TIME 1120
DEPTH, FT 45 REFERENCE FIG. 4-27

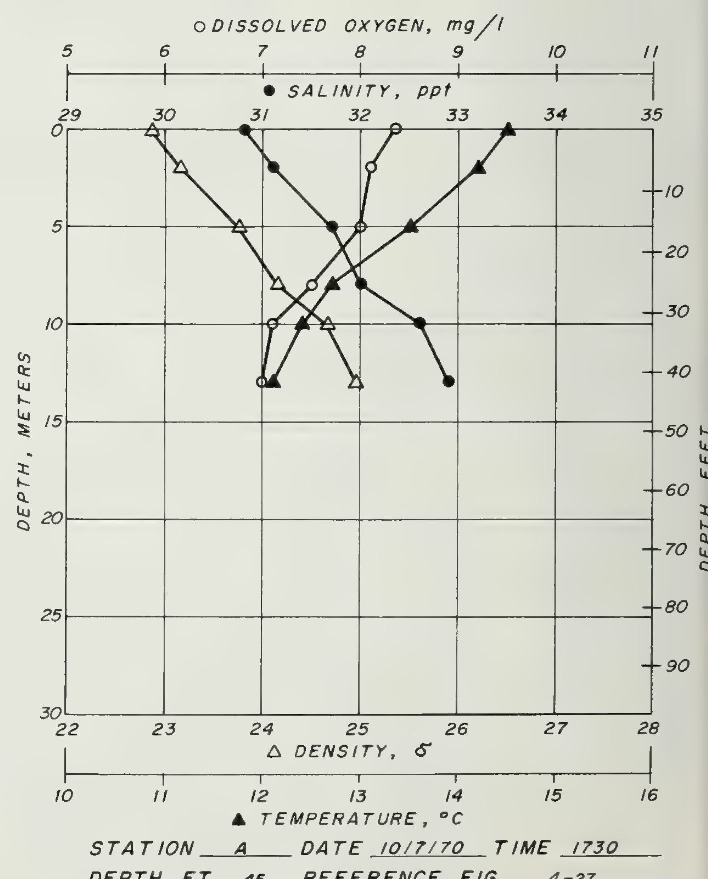


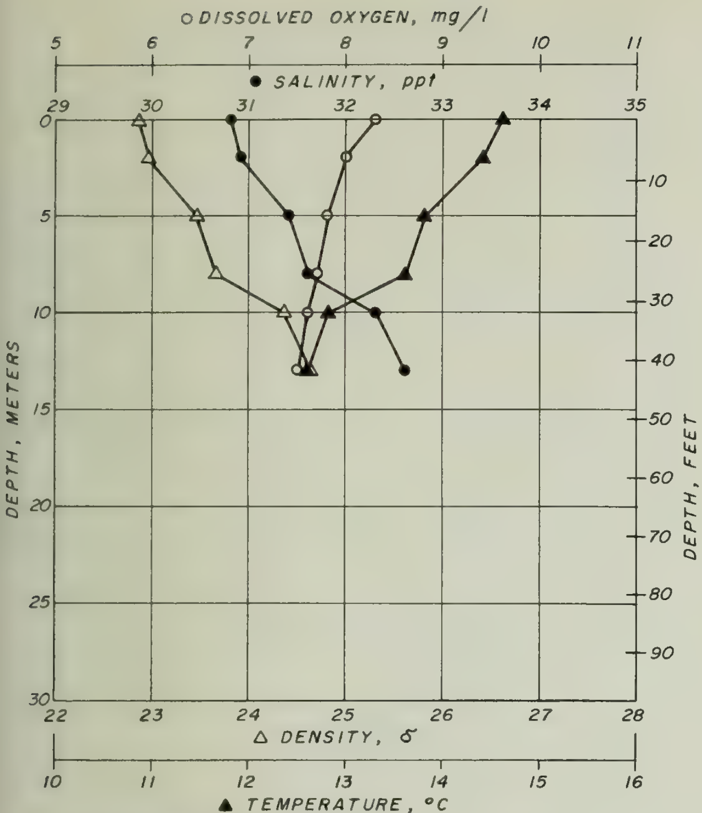
STATION A DATE 10/7/70 TIME 1230
DEPTH, FT 45 REFERENCE FIG. 4-27


O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION A DATE 10/7/70 TIME 1331
DEPTH, FT 45 REFERENCE FIG. 4-27

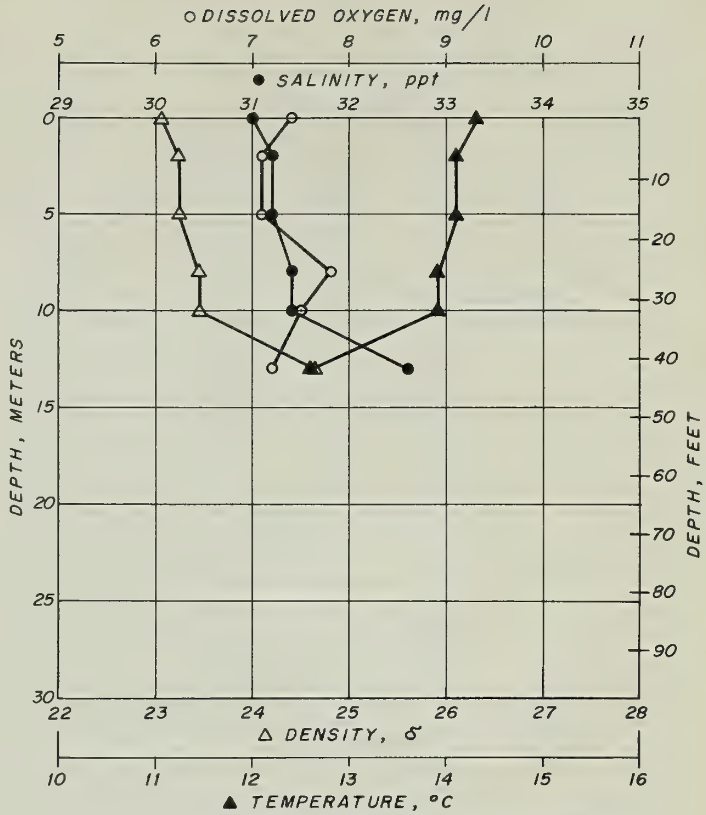

O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION A DATE 10/7/70 TIME 1526
DEPTH, FT 45 REFERENCE FIG. 4-27


O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION A DATE 10/7/70 TIME 1638
DEPTH, FT 45 REFERENCE FIG. 4-27

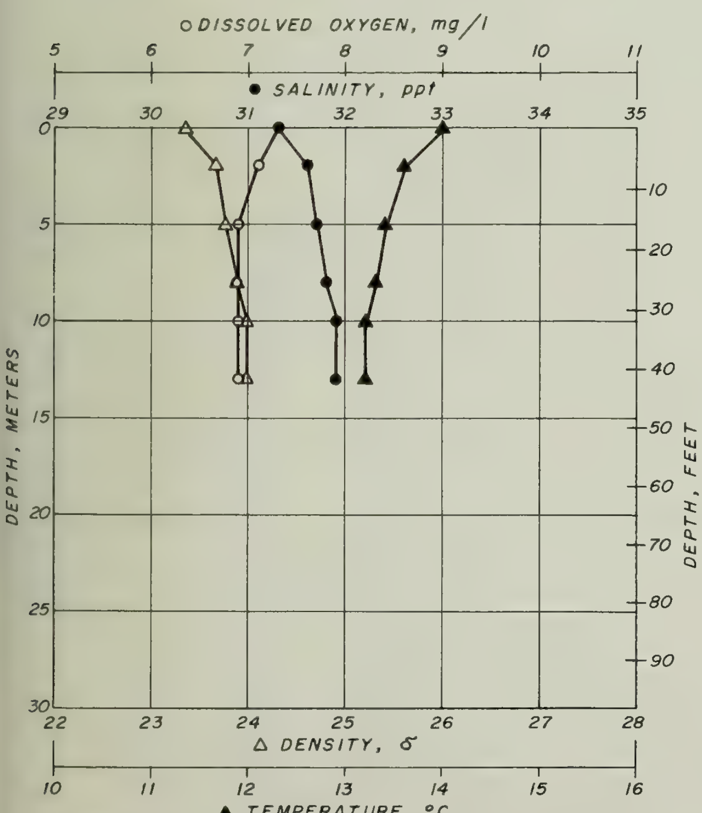

O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION A DATE 10/7/70 TIME 1730
DEPTH, FT 45 REFERENCE FIG. 4-27



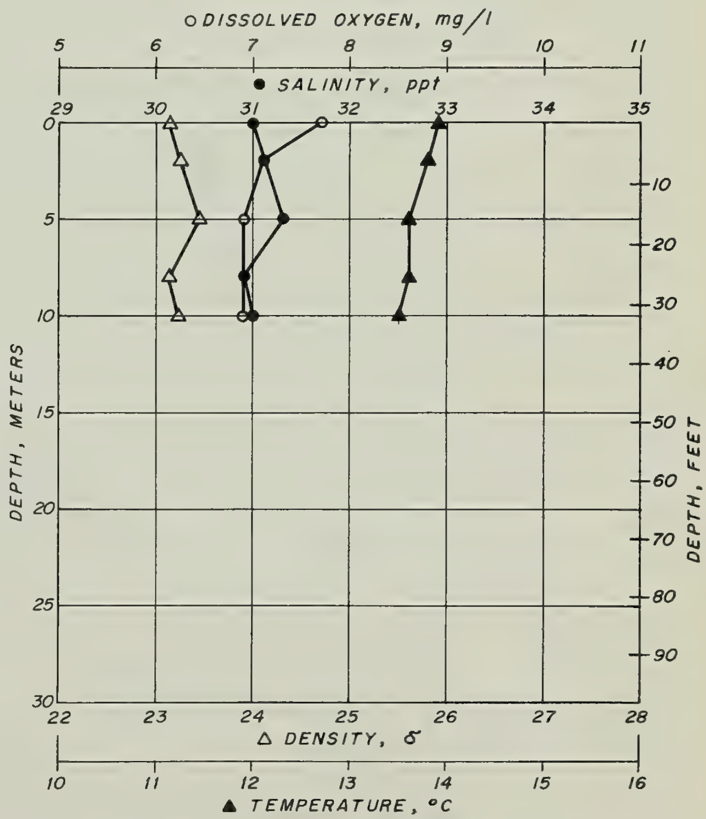
STATION A DATE 10/7/70 TIME 1828
DEPTH, FT 45 REFERENCE FIG. 4-27



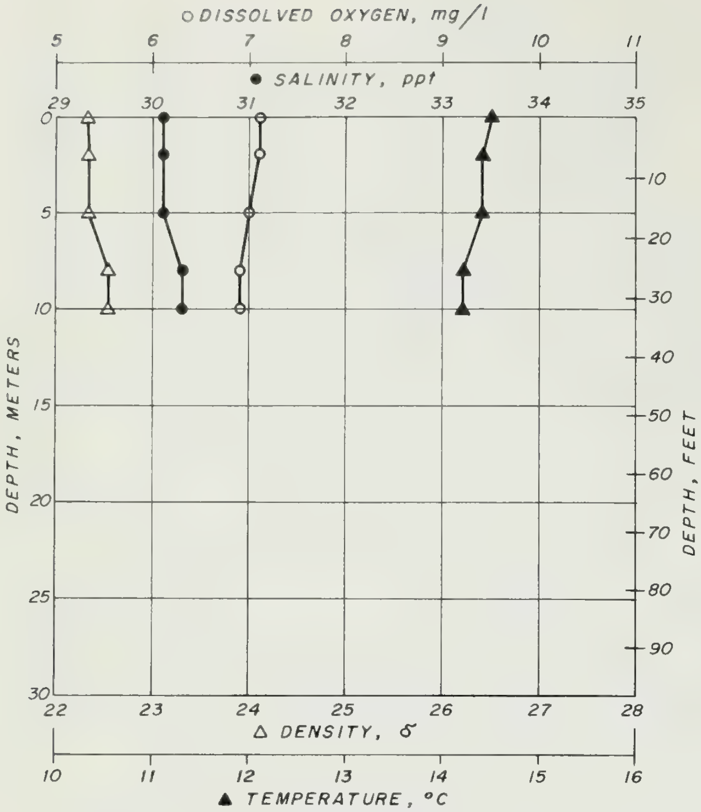
STATION A DATE 10/7/70 TIME 1926
DEPTH, FT 45 REFERENCE FIG. 4-27



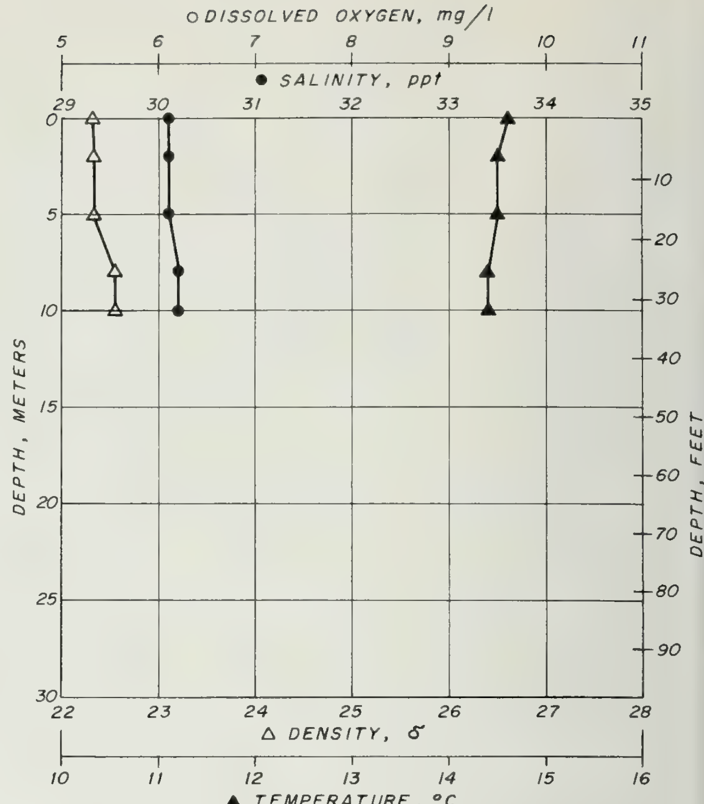
STATION A DATE 10/7/70 TIME 2132
DEPTH, FT 45 REFERENCE FIG. 4-27



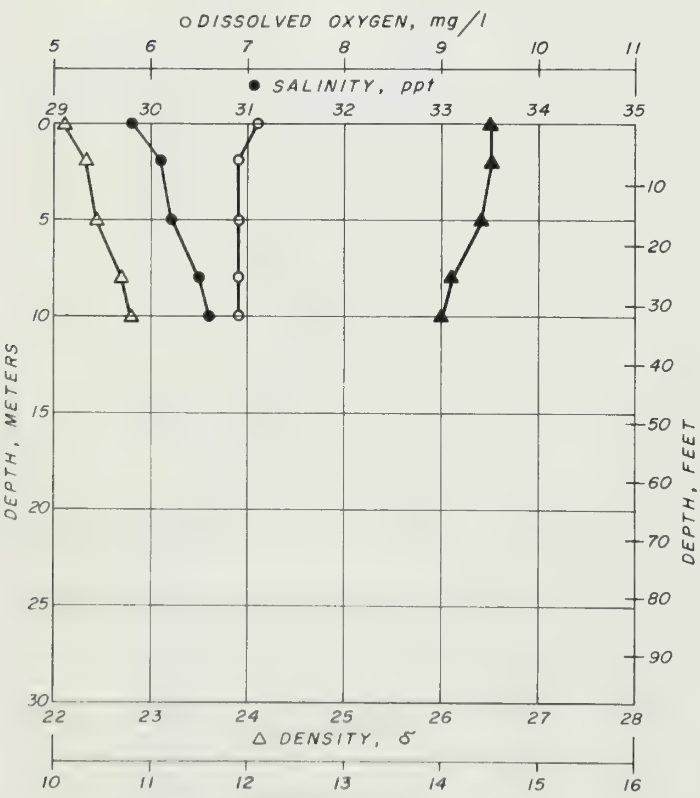
STATION A DATE 10/7/70 TIME 2230
DEPTH, FT 45 REFERENCE FIG. 4-27



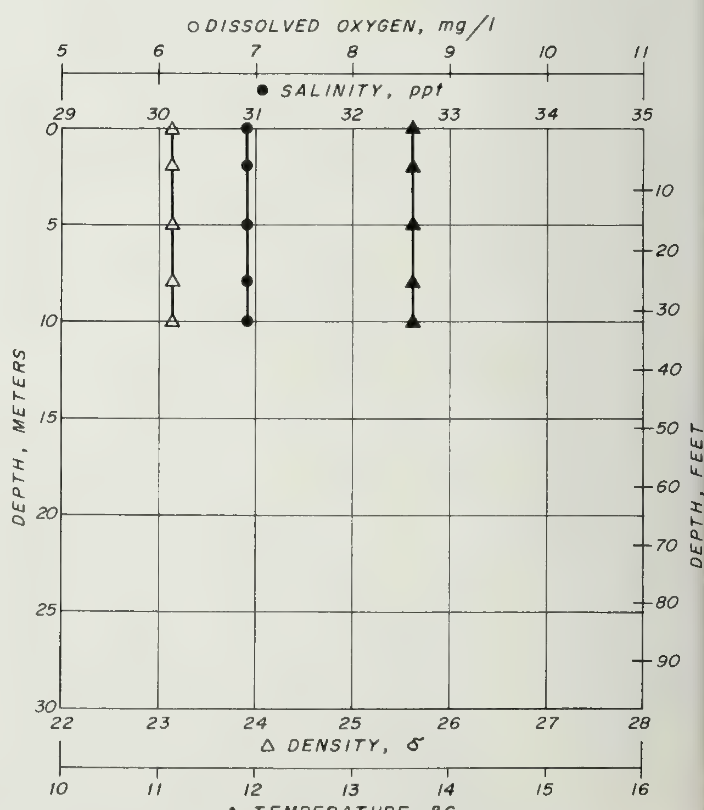
STATION A DATE 10/7/70 TIME 2330
DEPTH, FT 45 REFERENCE FIG. 4-27



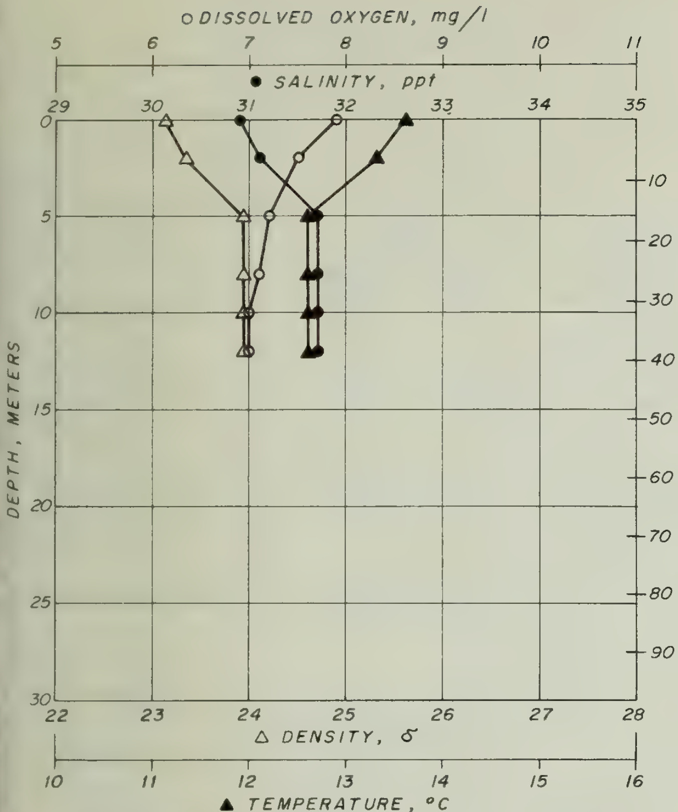
STATION A DATE 10/8/70 TIME 0030
DEPTH, FT 45 REFERENCE FIG. 4-27



STATION A DATE 10/8/70 TIME 0125
DEPTH, FT 45 REFERENCE FIG. 4-27

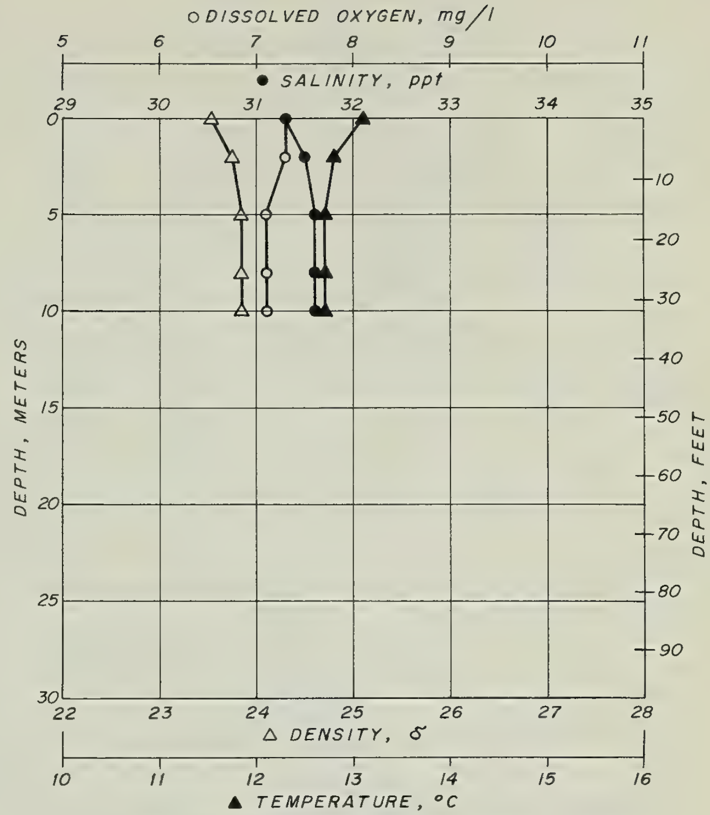


STATION A DATE 10/8/70 TIME 0325
DEPTH, FT 45 REFERENCE FIG. 4-27



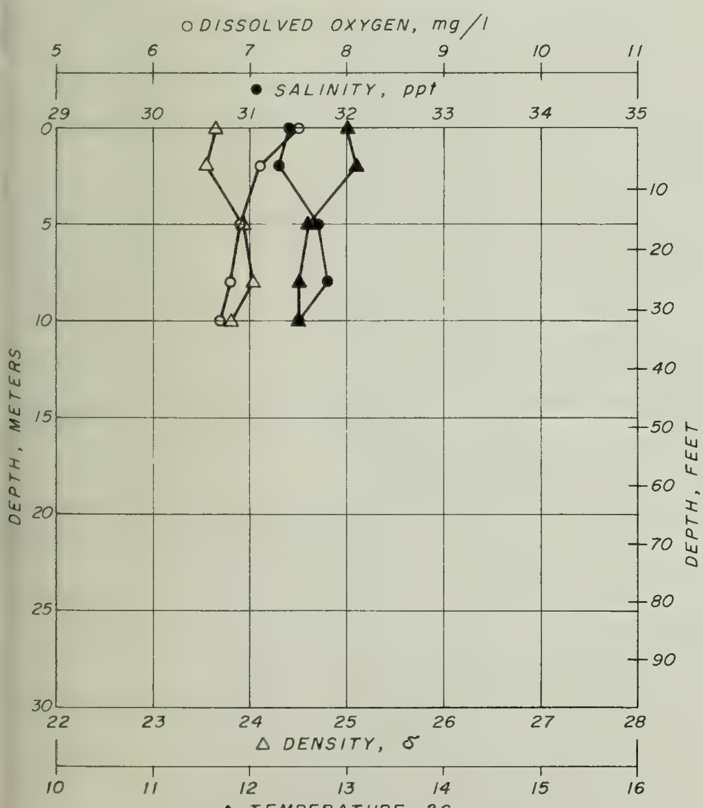
STATION A DATE 10/8/70 TIME 0446

DEPTH, FT 45 REFERENCE FIG. 4-27



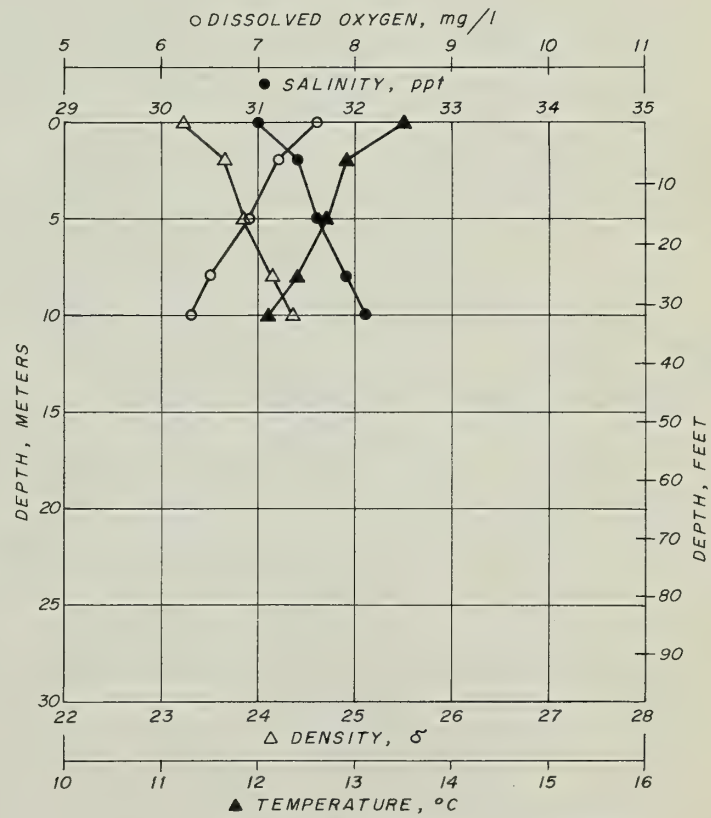
STATION A DATE 10/8/70 TIME 0547

DEPTH, FT 45 REFERENCE FIG. 4-27



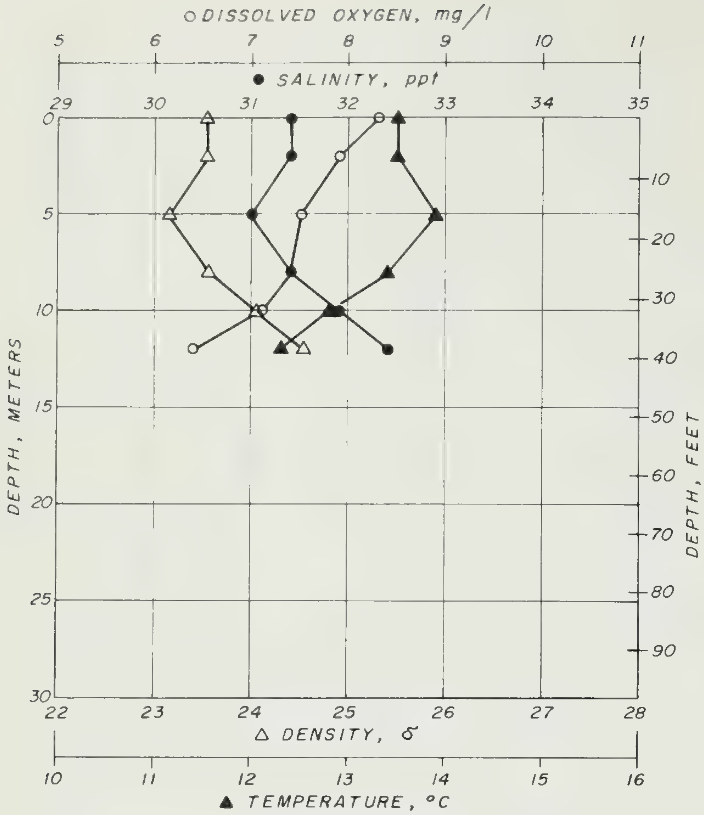
STATION A DATE 10/8/70 TIME 0639

DEPTH, FT 45 REFERENCE FIG. 4-27

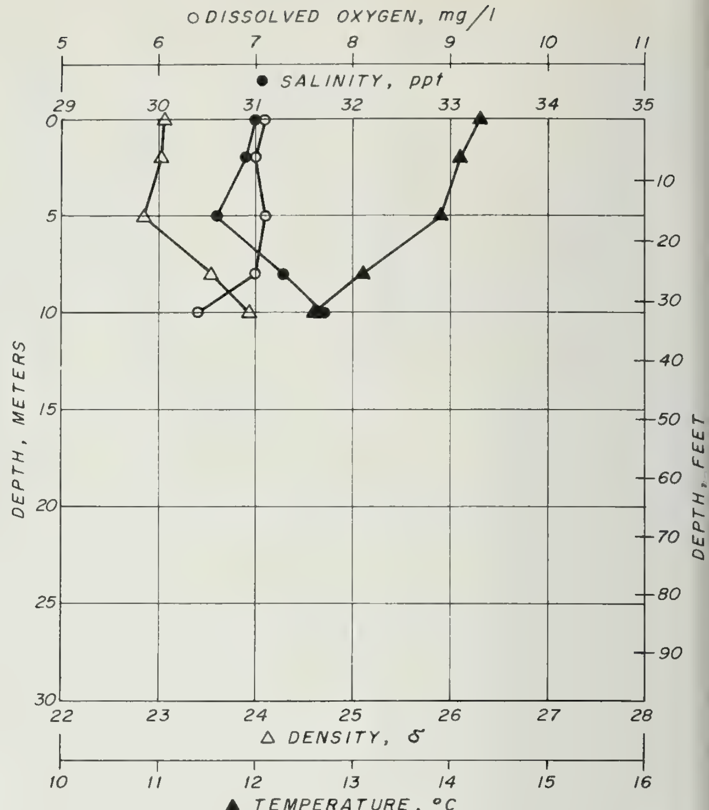


STATION A DATE 10/8/70 TIME 0739

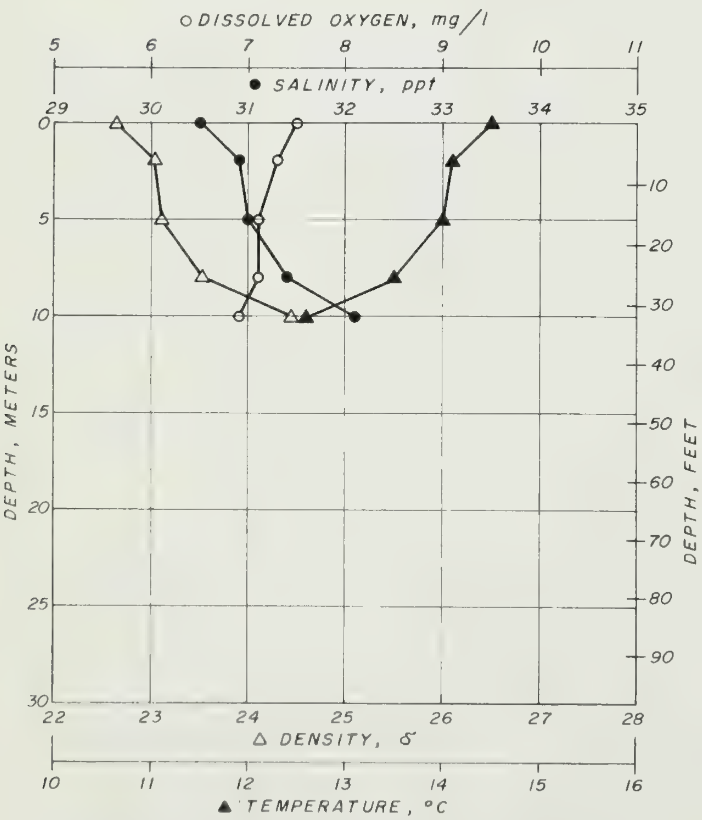
DEPTH, FT 45 REFERENCE FIG. 4-27



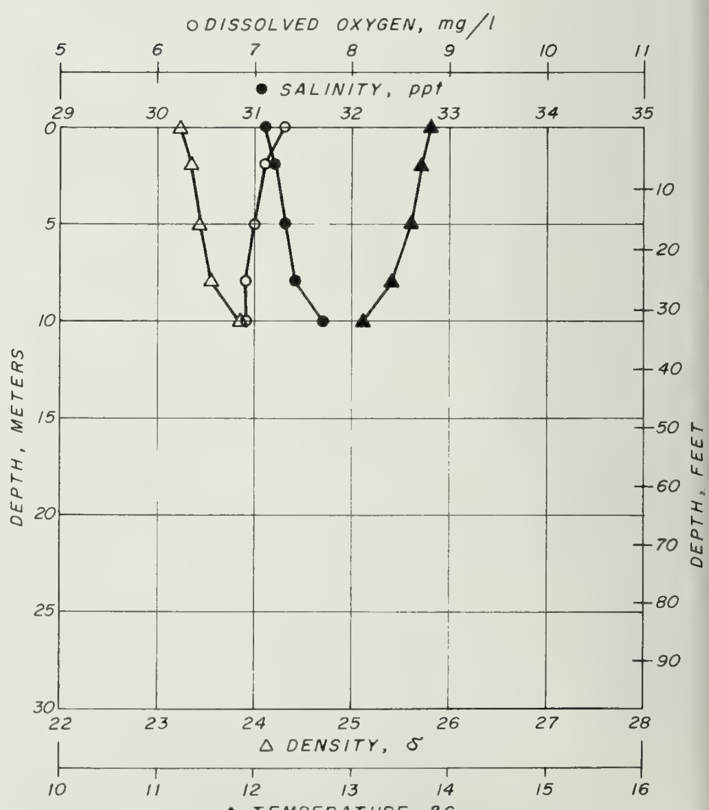
STATION A DATE 10/8/70 TIME 0941
DEPTH, FT 45 REFERENCE FIG. 4-27



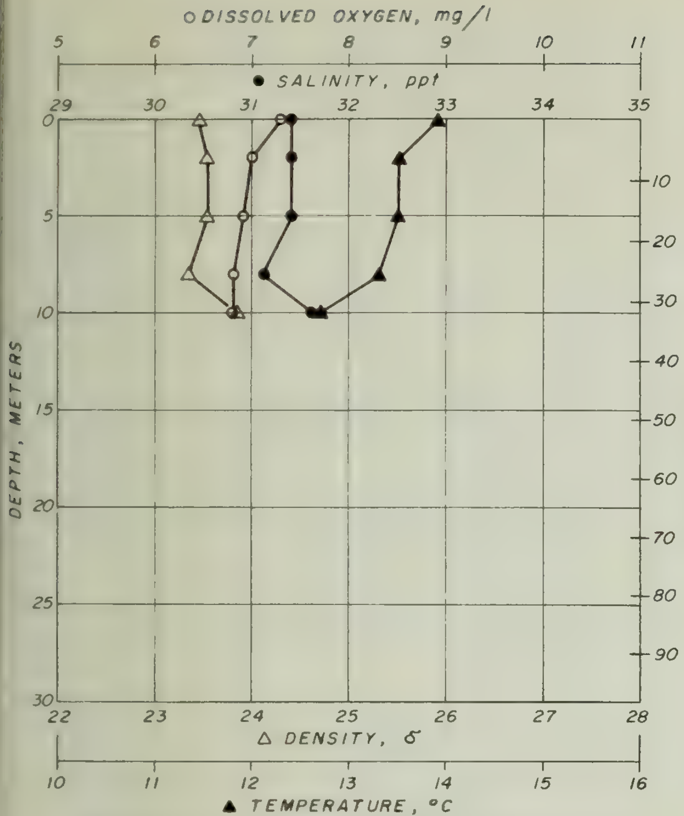
STATION A DATE 10/8/70 TIME 1036
DEPTH, FT 45 REFERENCE FIG. 4-27



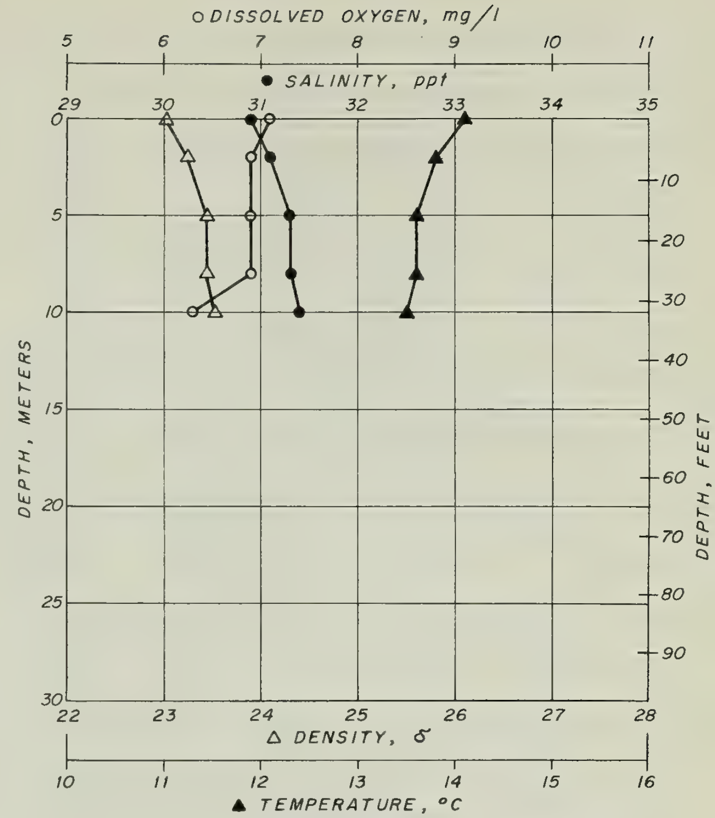
STATION A DATE 10/8/70 TIME 1127
DEPTH, FT 45 REFERENCE FIG. 4-27



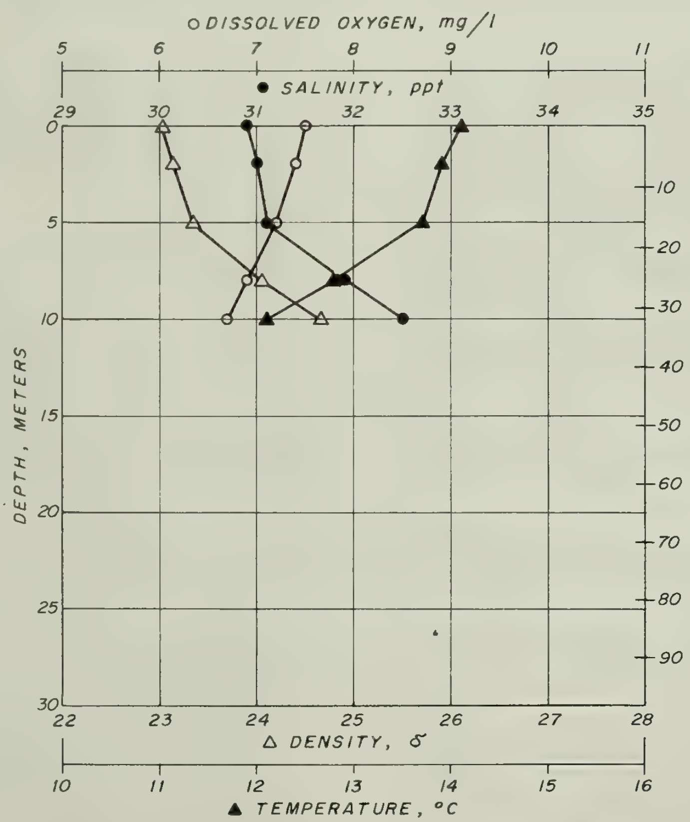
STATION A DATE 10/8/70 TIME 1229
DEPTH, FT 45 REFERENCE FIG. 4-27



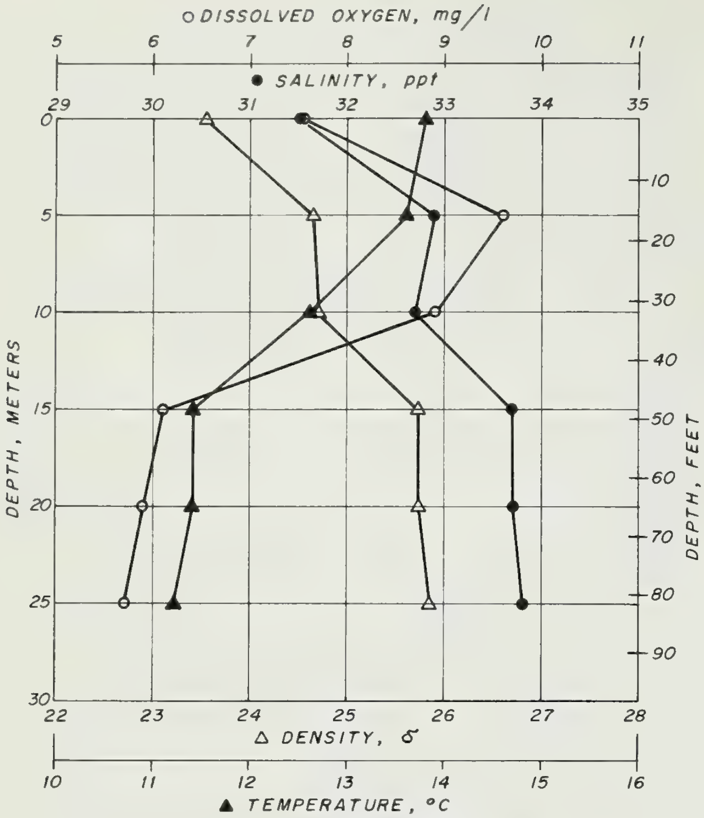
STATION A DATE 10/8/70 TIME 1327
DEPTH, FT 45 REFERENCE FIG. 4-27



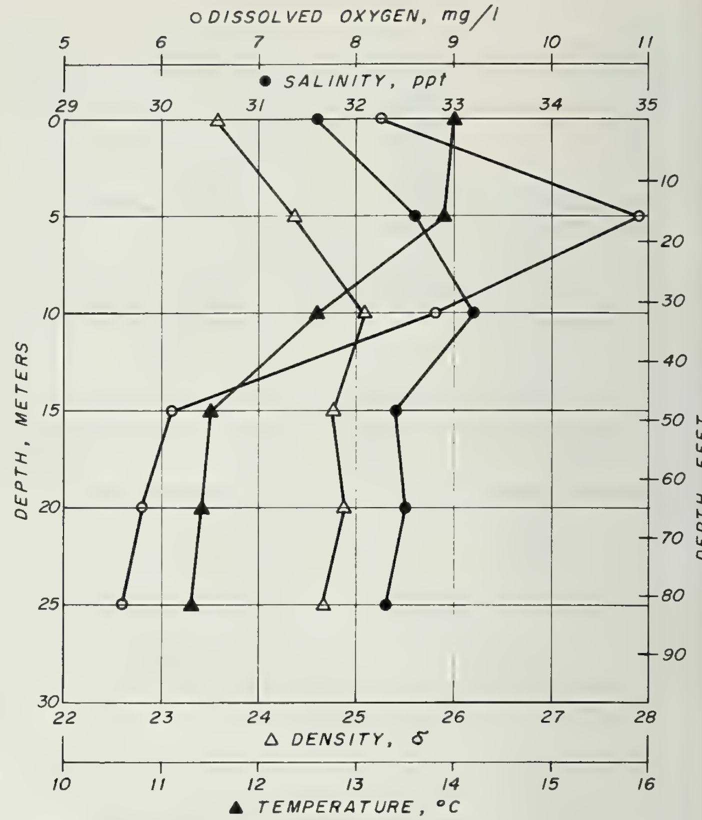
STATION A DATE 10/8/70 TIME 1432
DEPTH, FT 45 REFERENCE FIG. 4-27



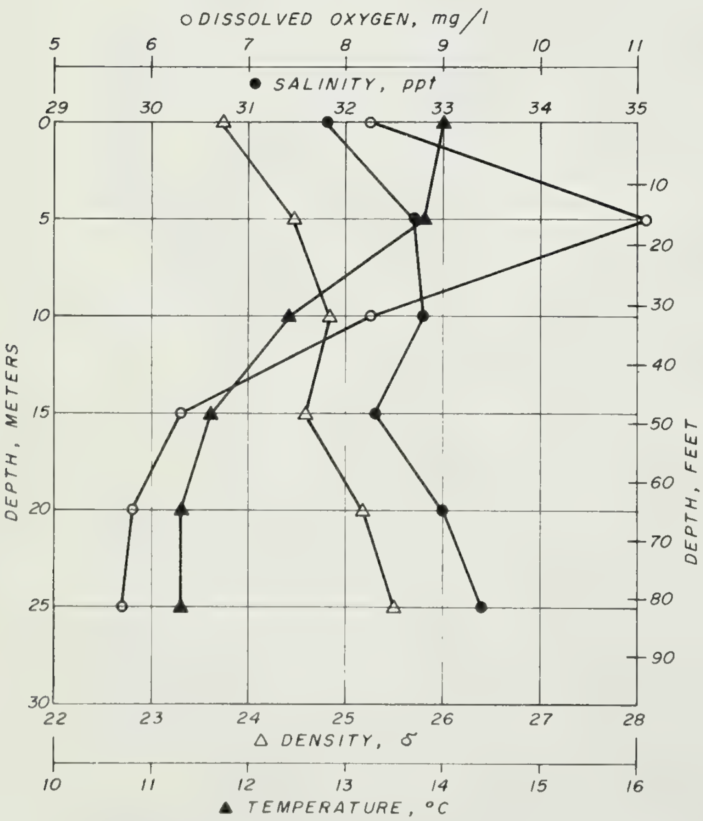
STATION A DATE 10/8/70 TIME 1528
DEPTH, FT 45 REFERENCE FIG. 4-27



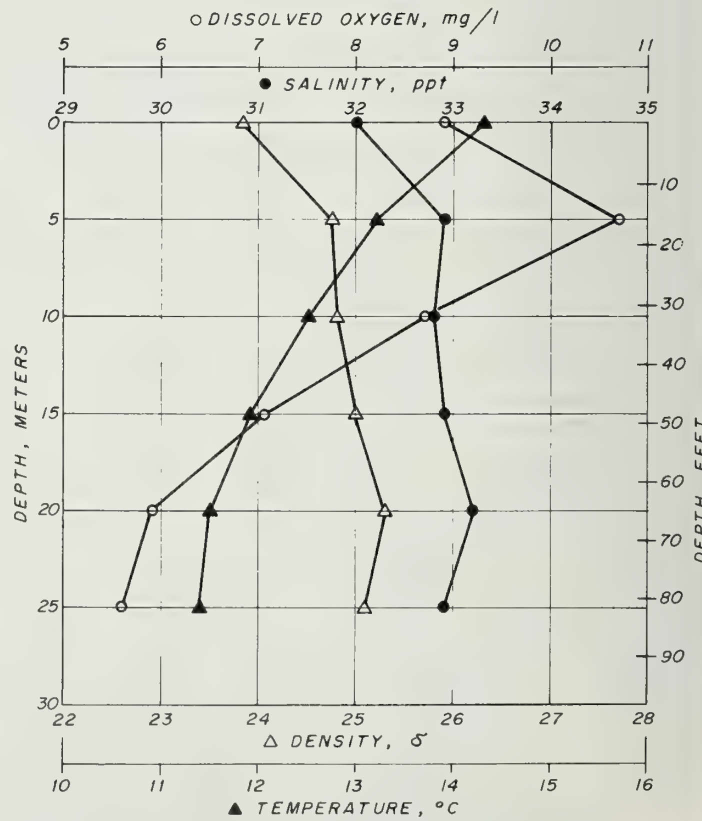
STATION B DATE 10/10/70 TIME 0920
DEPTH, FT 90 REFERENCE FIG. 4-27



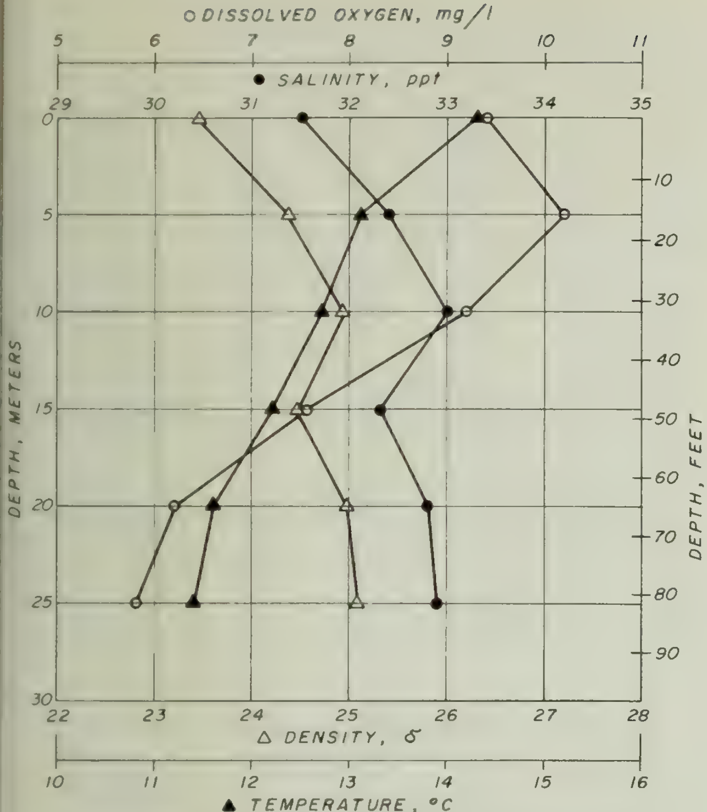
STATION B DATE 10/10/70 TIME 1035
DEPTH, FT 90 REFERENCE FIG. 4-27



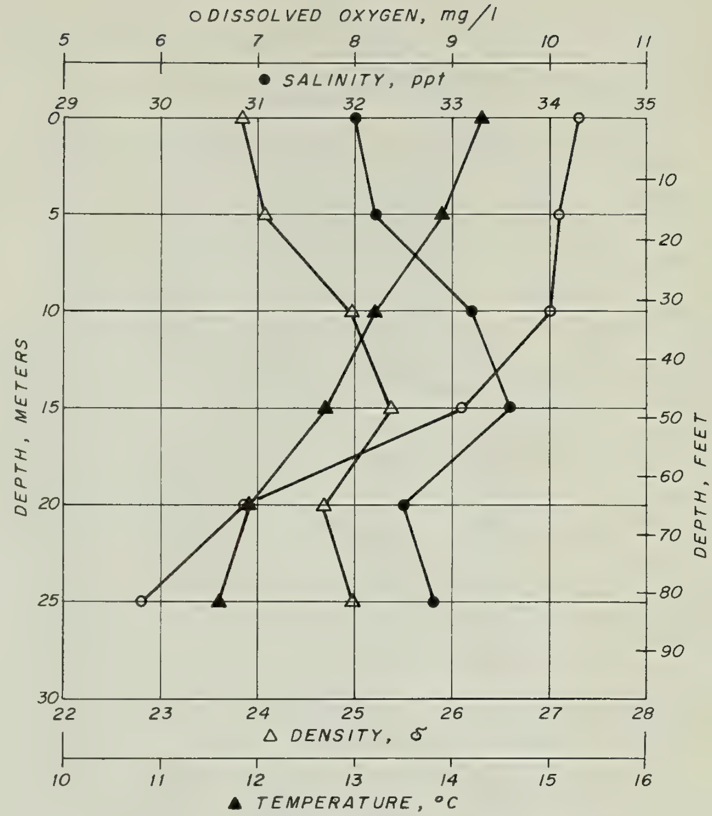
STATION B DATE 10/10/70 TIME 1129
DEPTH, FT 90 REFERENCE FIG. 4-27



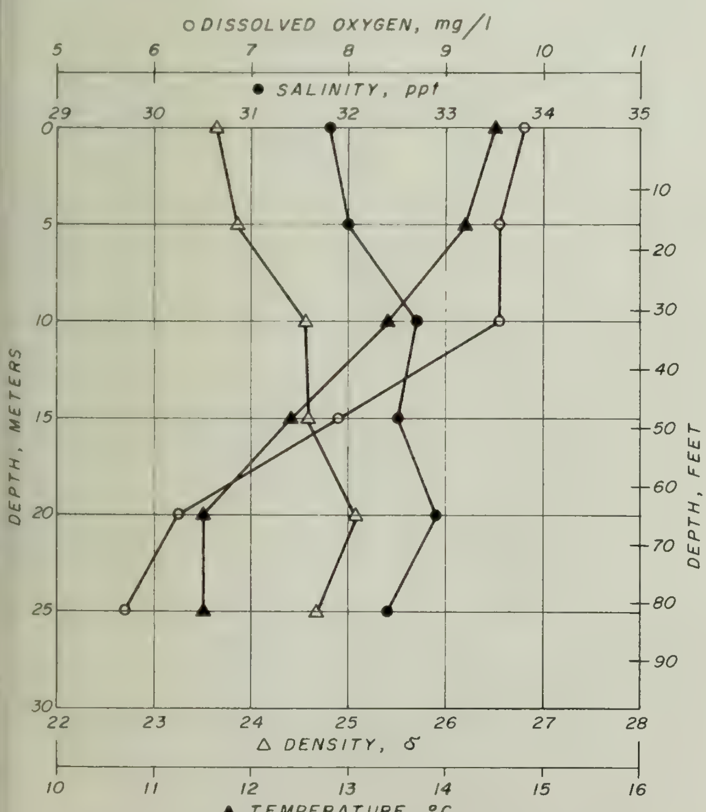
STATION B DATE 10/10/70 TIME 1229
DEPTH, FT 90 REFERENCE FIG. 4-27



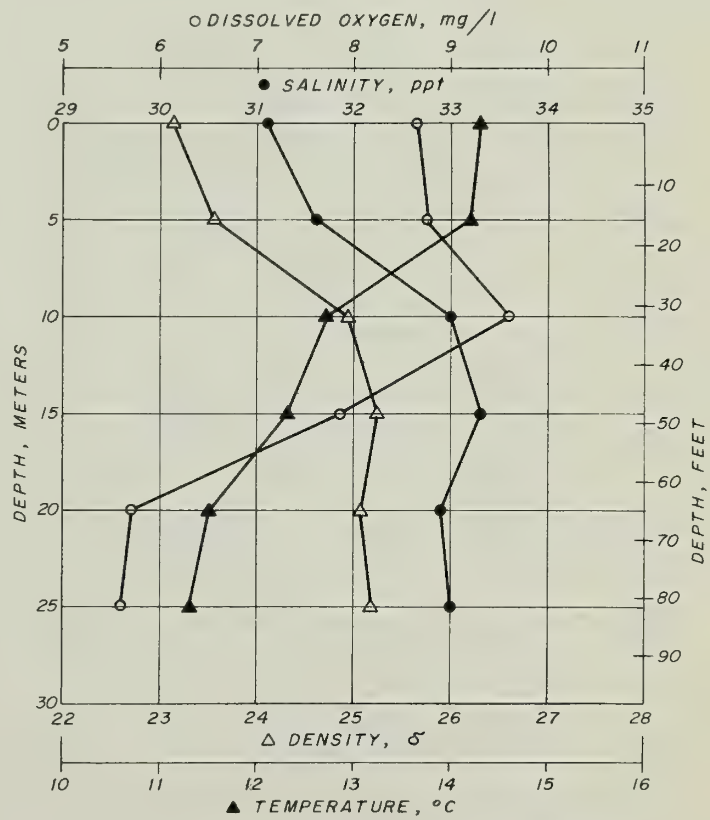
STATION B DATE 10/10/70 TIME 1332
DEPTH, FT 90 REFERENCE FIG. 4-27



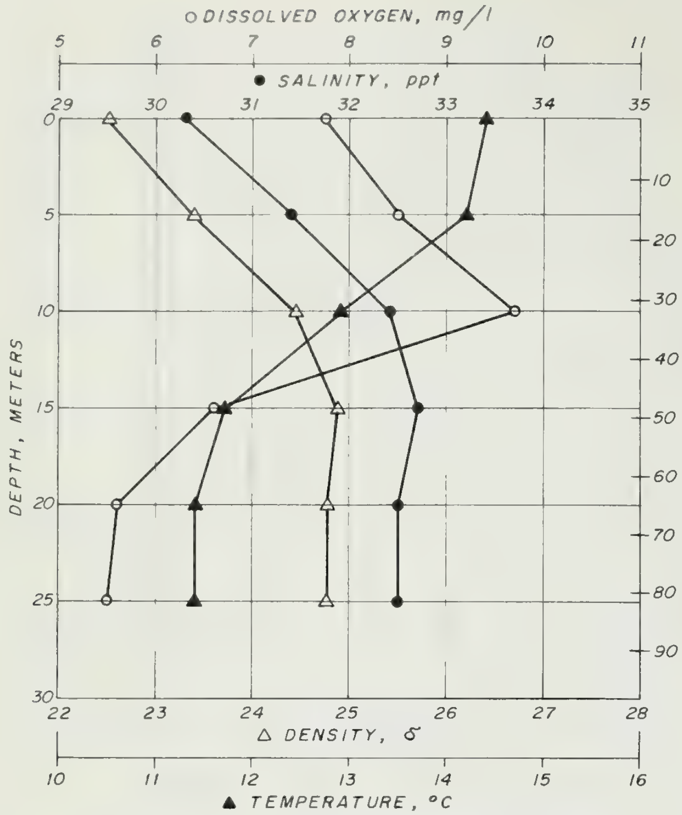
STATION B DATE 10/10/70 TIME 1430
DEPTH, FT 90 REFERENCE FIG. 4-27



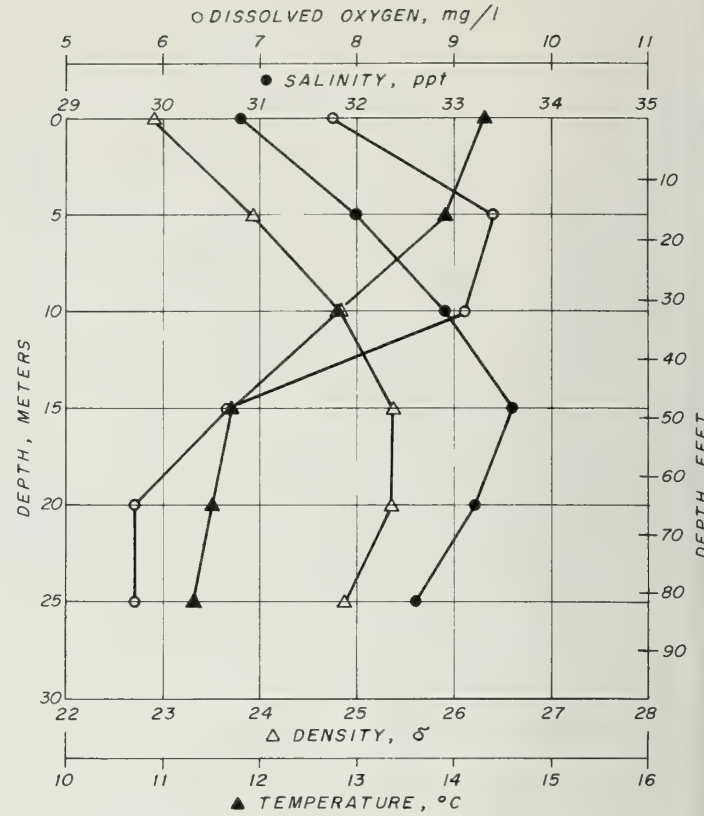
STATION B DATE 10/10/70 TIME 1532
DEPTH, FT 90 REFERENCE FIG. 4-27



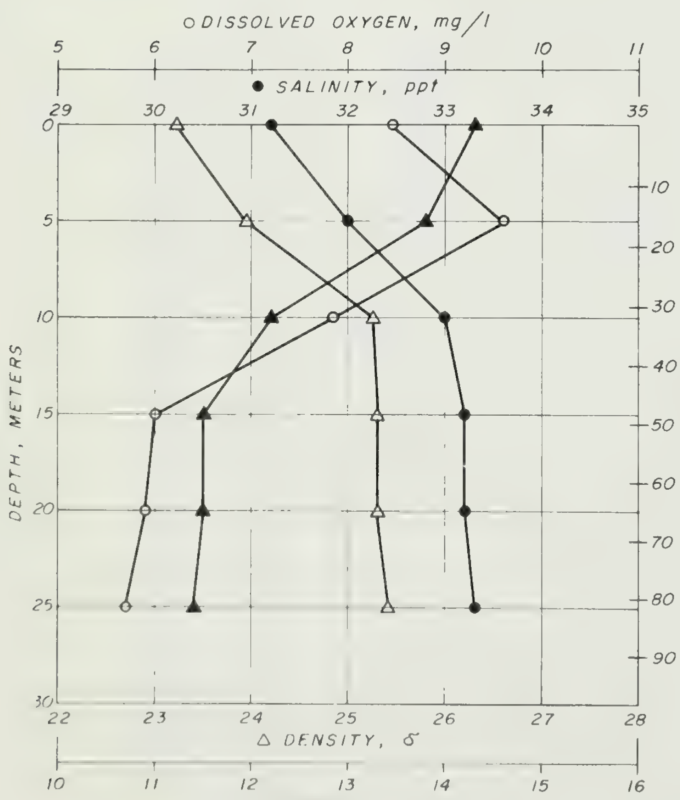
STATION B DATE 10/10/70 TIME 1632
DEPTH, FT 90 REFERENCE FIG. 4-27



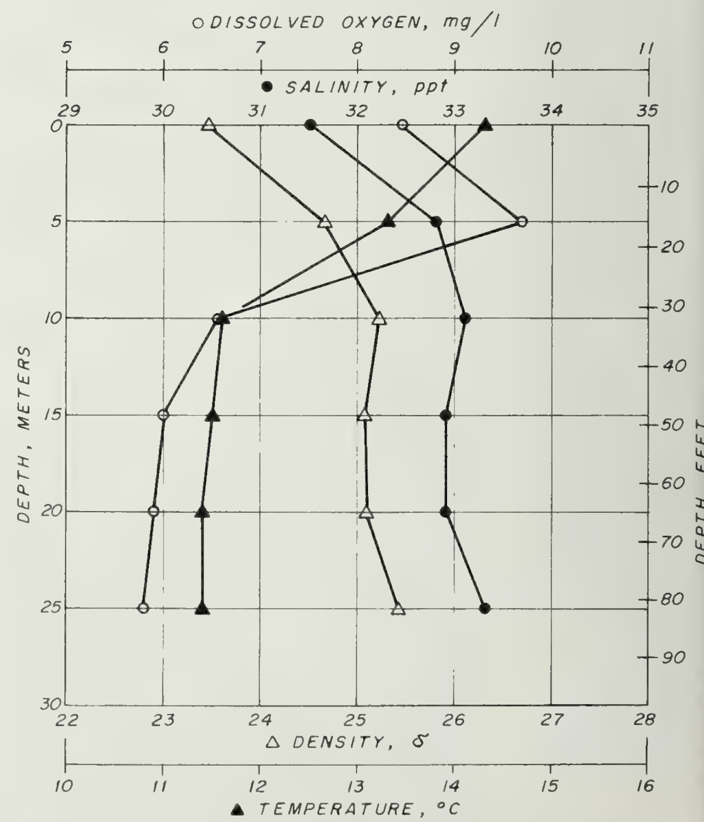
STATION B DATE 10/10/70 TIME 1730
DEPTH, FT 90 REFERENCE FIG. 4-27



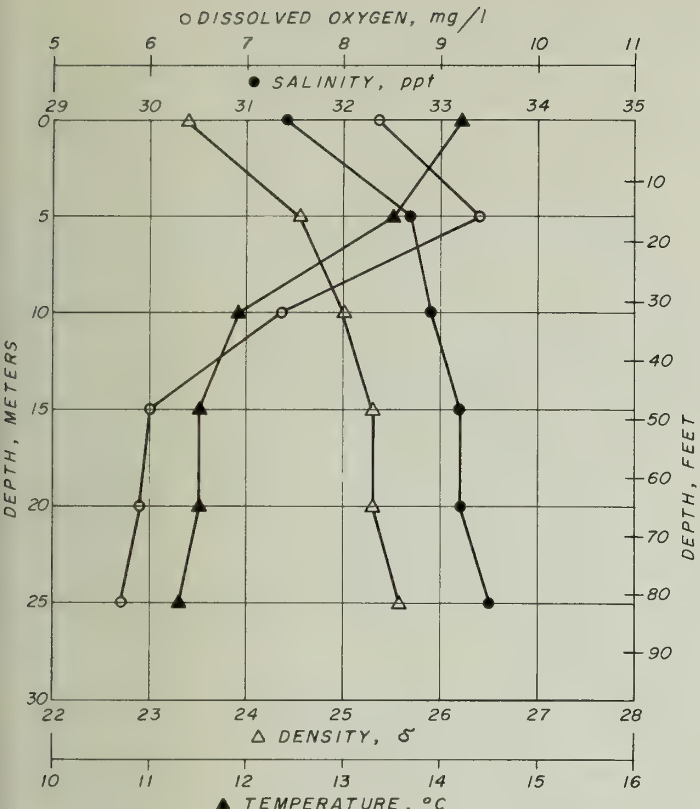
STATION B DATE 10/10/70 TIME 1831
DEPTH, FT 90 REFERENCE FIG. 4-27



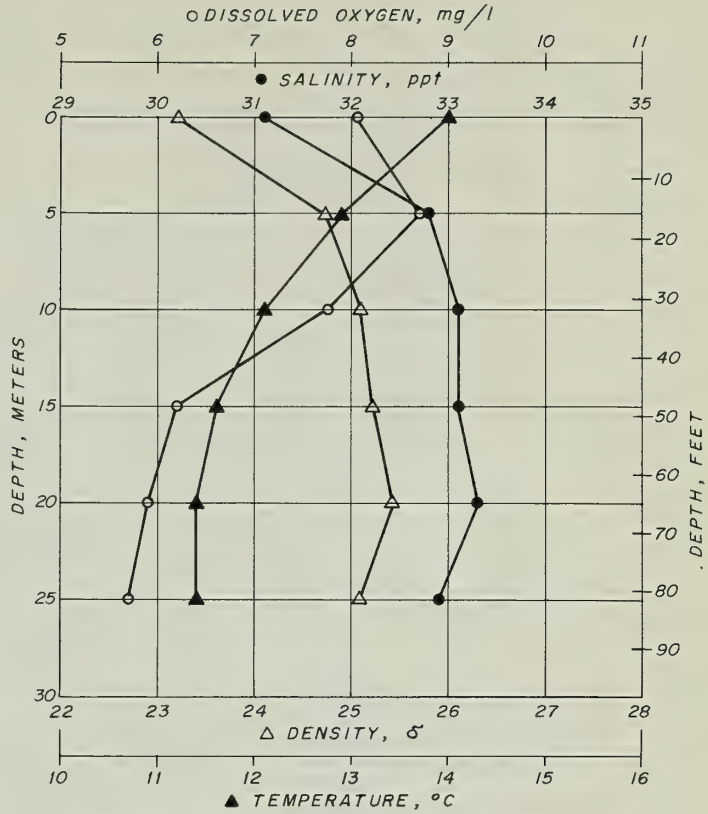
STATION B DATE 10/10/70 TIME 1929
DEPTH, FT 90 REFERENCE FIG 4-27



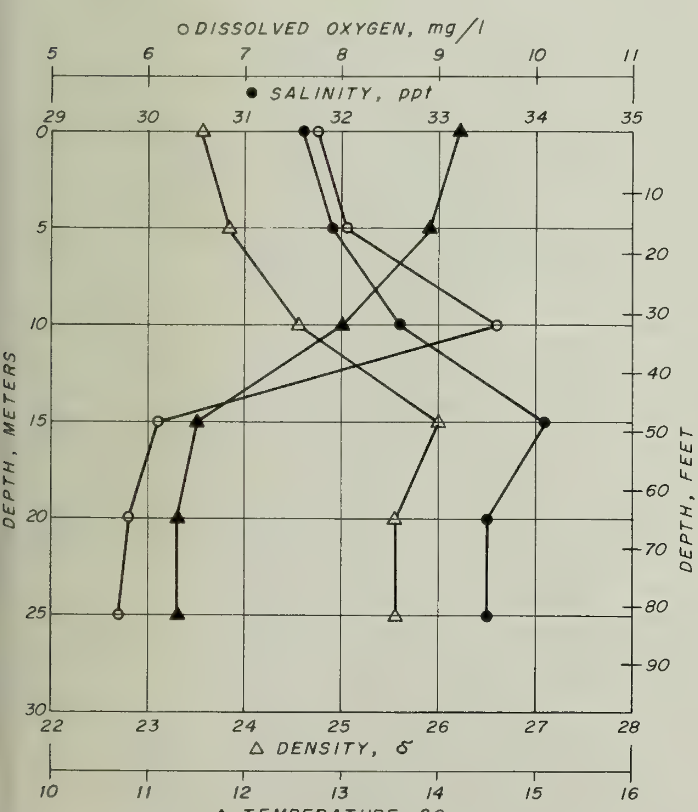
STATION B DATE 10/10/70 TIME 2031
DEPTH, FT 90 REFERENCE FIG. 4-27



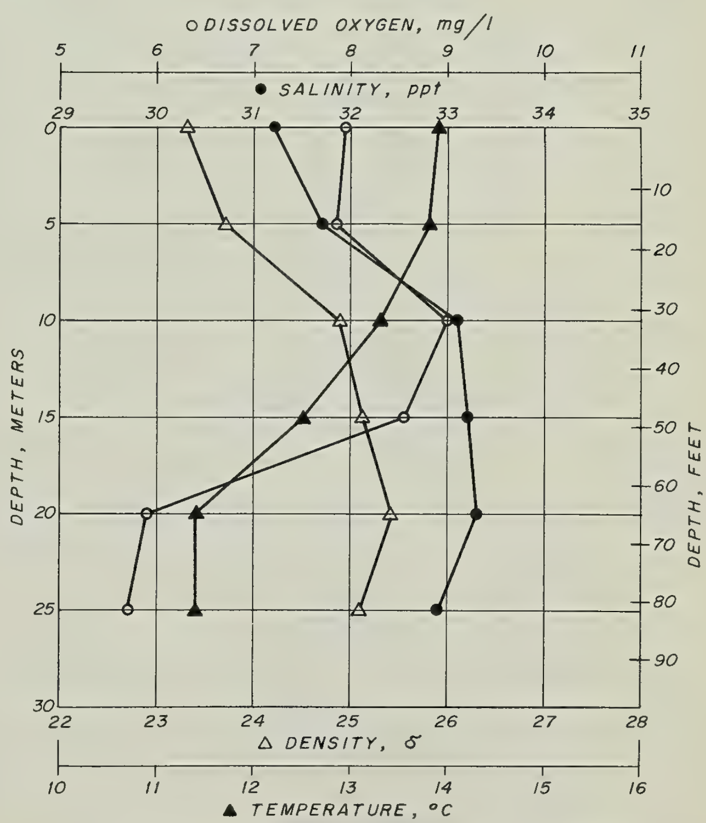
STATION B DATE 10/10/70 TIME 2128
DEPTH, FT 90 REFERENCE FIG. 4-27



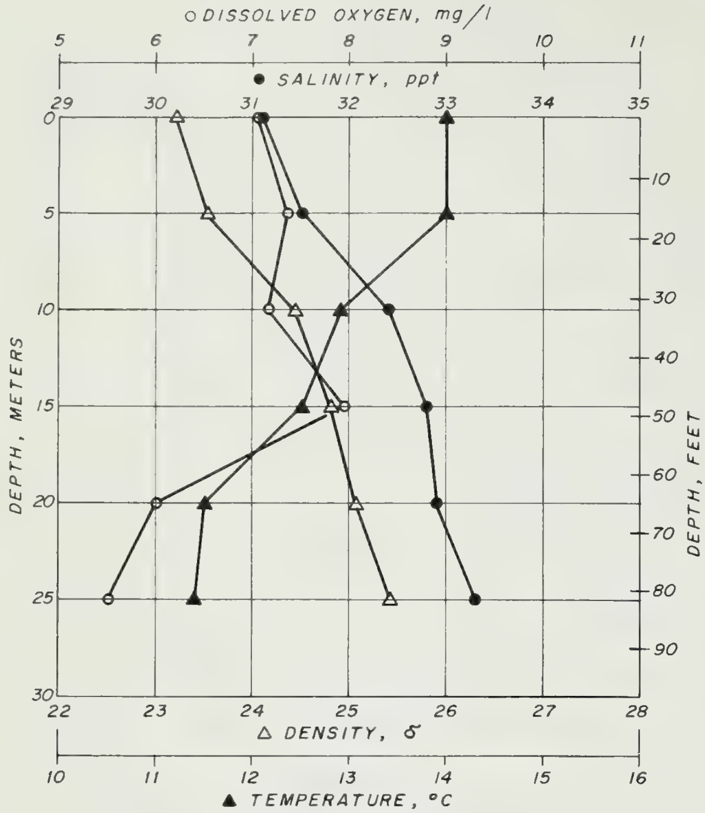
STATION B DATE 10/10/70 TIME 2230
DEPTH, FT 90 REFERENCE FIG. 4-27



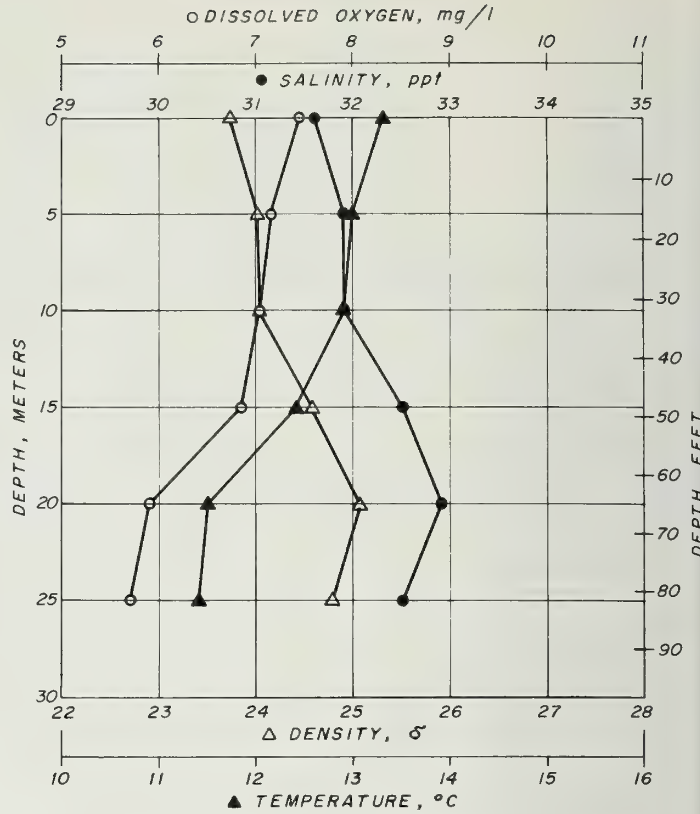
STATION B DATE 10/10/70 TIME 2330
DEPTH, FT 90 REFERENCE FIG. 4-27



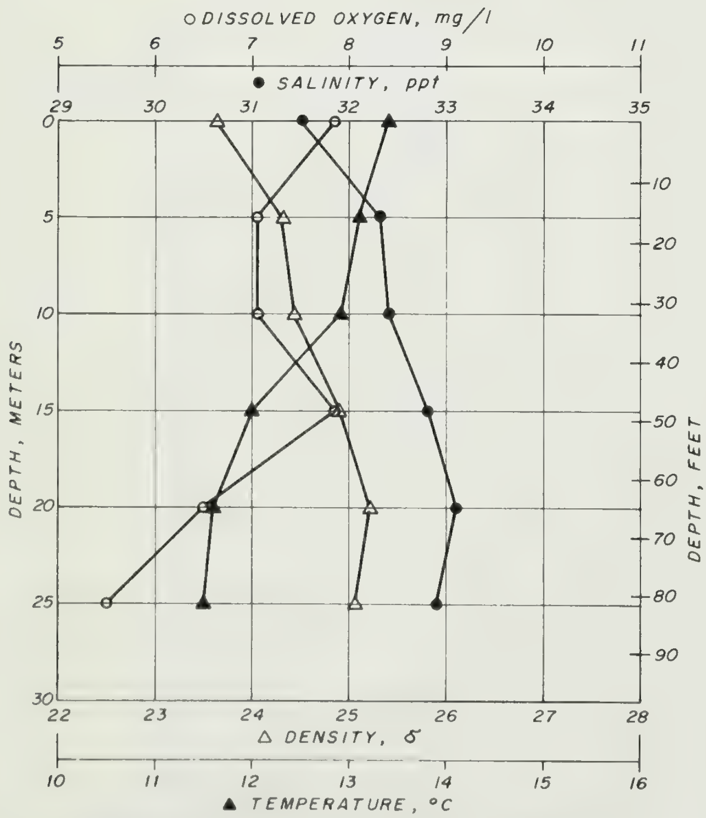
STATION B DATE 10/11/70 TIME 0030
DEPTH, FT 90 REFERENCE FIG. 4-27



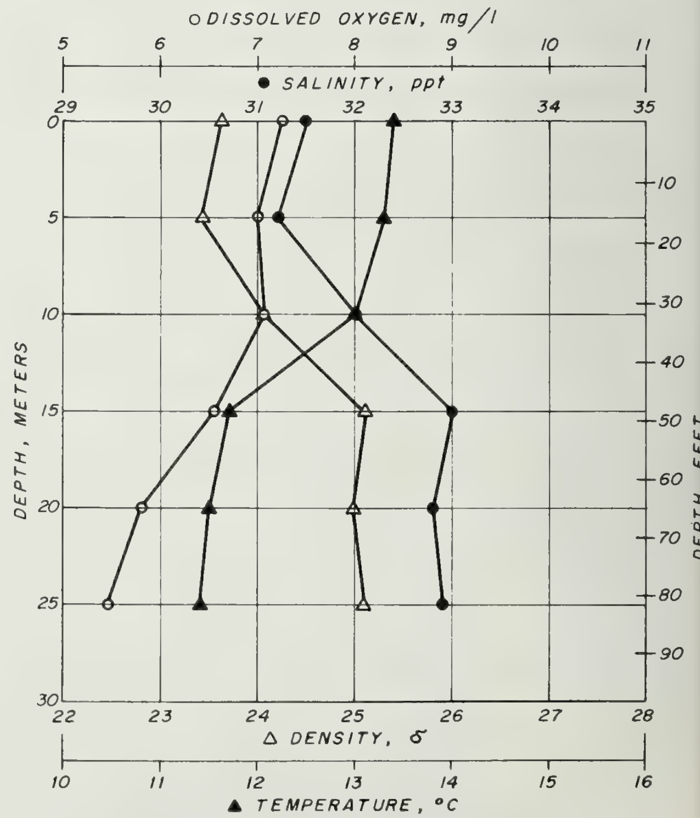
STATION B DATE 10/11/70 TIME 0130
DEPTH, FT 90 REFERENCE FIG. 4-27



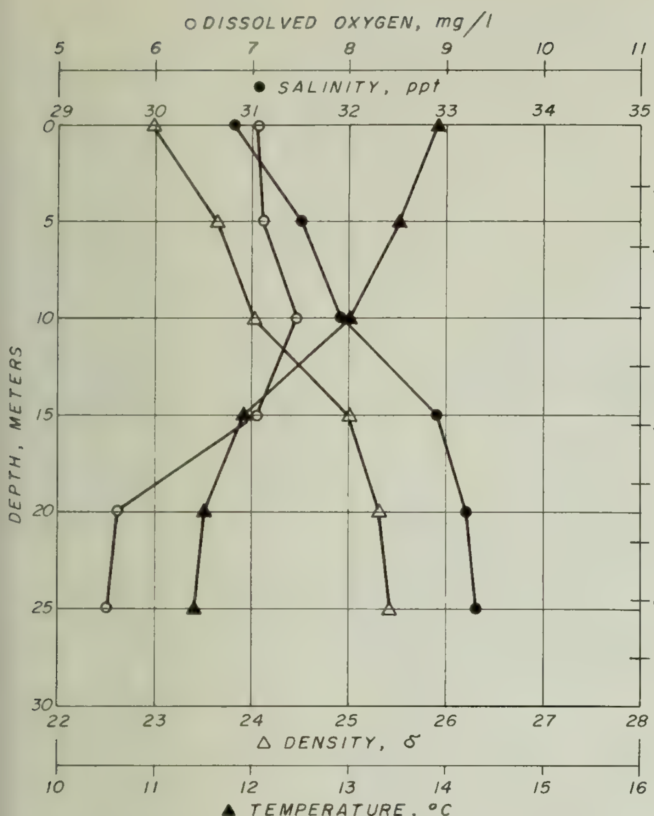
STATION B DATE 10/11/70 TIME 0229
DEPTH, FT 90 REFERENCE FIG. 4-27



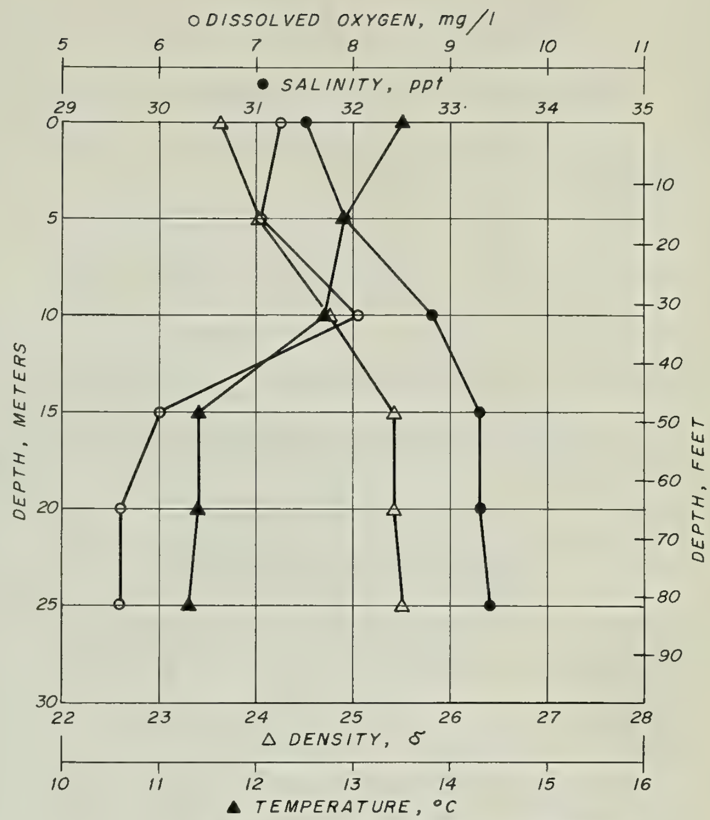
STATION B DATE 10/11/70 TIME 0330
DEPTH, FT 90 REFERENCE FIG. 4-27



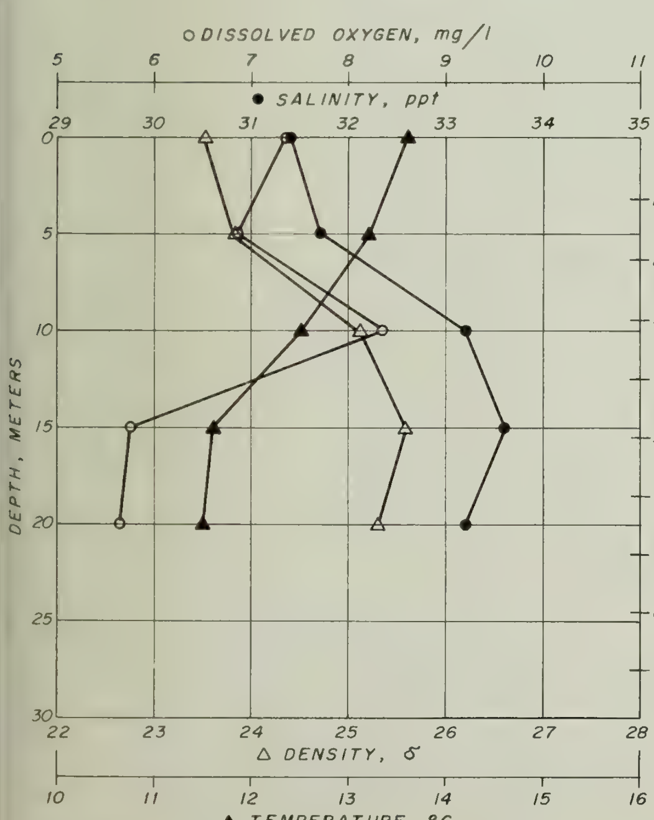
STATION B DATE 10/11/70 TIME 0430
DEPTH, FT 90 REFERENCE FIG. 4-27



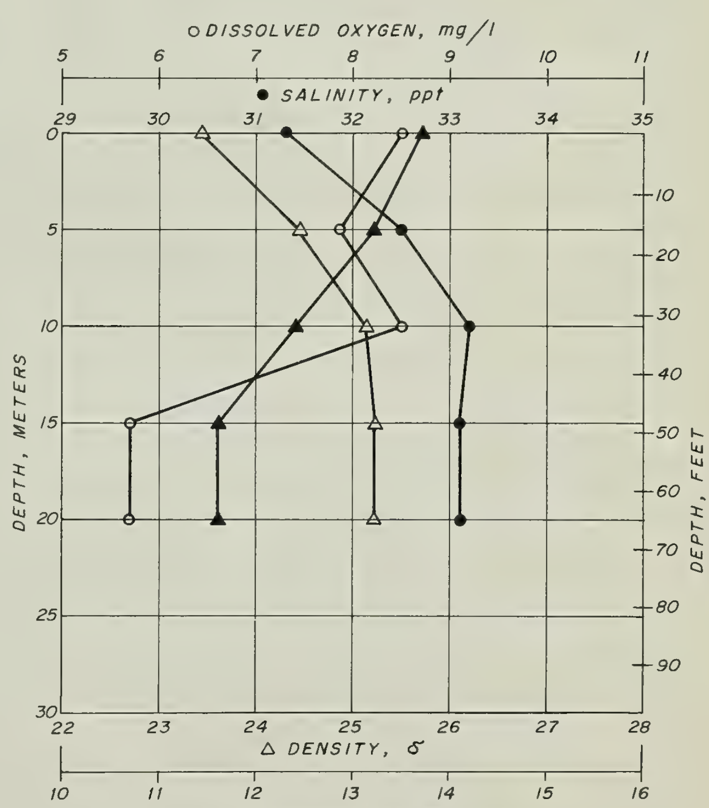
STATION B DATE 10/11/70 TIME 0530
DEPTH, FT 90 REFERENCE FIG. 4-27



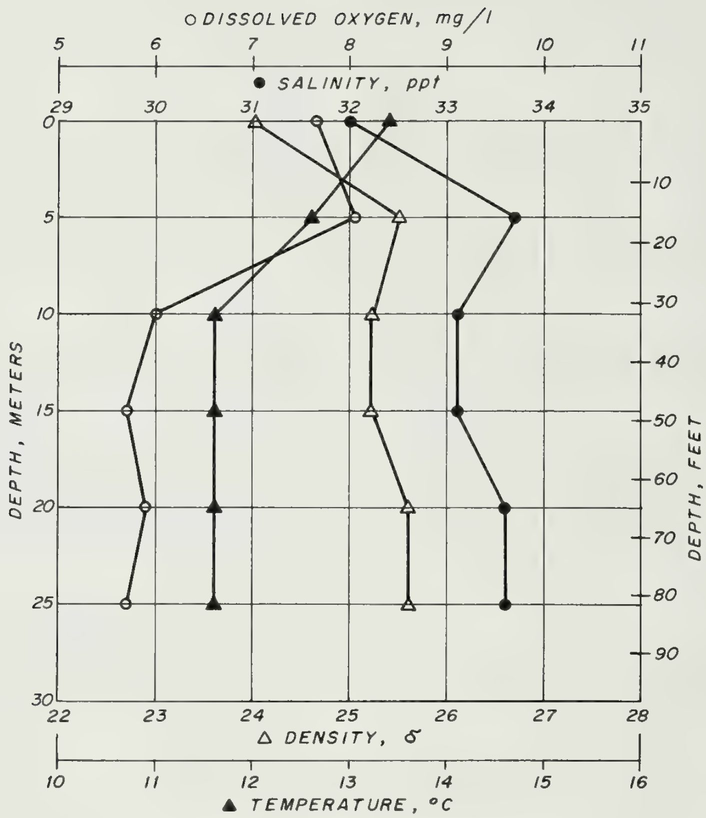
STATION B DATE 10/11/70 TIME 0630
DEPTH, FT 90 REFERENCE FIG. 4-27



STATION B DATE 10/11/70 TIME 0751
DEPTH, FT 90 REFERENCE FIG. 4-27



STATION B DATE 10/11/70 TIME 0852
DEPTH, FT 90 REFERENCE FIG. 4-27



STATION B DATE 10/11/70 TIME 1017
DEPTH, FT 90 REFERENCE FIG. 4-27

Gulf of the Farallones Currents Winter Season

Table 1. Winter Current Data, Gulf of the Farallones

Date Collected: February 3 and 4, 1970

Meter Type: Hydro Products in-situ recording current meter

Station: Reference figure: Water depth, feet: Meter depth, feet:	97 4-12 40 15		98 4-12 40 15		99 4-12 75 15		99 4-12 75 60	
Time, PST	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
February 3, 1970								
0830					0.8	95		20
0900			0.7	215	0.9	175		55
0930			0.7	220	0.8	205		95
1000			0.8	230	1.1	225		215
1030	2.0	325	0.8	235	1.3	235		205
1100	2.1	325	0.9	245	1.6	255		210
1130	1.9	325	0.9	245	1.9	265		265
1200	1.7	330	0.8	235	1.9	270		285
1230	2.2	335	0.8	245	1.8	270		285
1300	2.3	330	0.8	255	1.8	265		285
1330	2.3	330	0.7	265	1.8	265	No	285
1400	2.2	330	0.6	270	1.7	265	record	285
1430	2.2	325	0.5	295	1.5	260		275
1500	2.2	325	0.5	325	1.1	255		265
1530	2.2	320	0.5	45	0.5	245		350
1600	1.4	315	0.6	35	0.5	240		355
1630	1.3	325	0.7	40	0.4	215		5
1700	1.2	350	0.7	30	0.6	125		5
1730	0.9	15	0.7	30	0.7	115		5
1800	0.8	40	0.7	25	1.1	105		15
1830	1.1	120	0.8	30	1.6	85		20
1900	1.1	125	0.8	25	1.7	65		15
1930	1.4	145	0.8	30	2.2	25		35
2000	1.0	145	0.8	25	2.0	25		40
2030	1.2	135	0.8	30	1.9	30		35
2100	0.8	145	0.8	30	1.8	30		40
2130	0.8	150	0.8	35	1.8	30		40
2200	0.9	180	0.6	35	1.7	25		30
2230	1.2	185	0.4	40	1.7	15		10
2300	1.2	190	0.4	55	0.6	165		5
2330	1.3	195	0.4	335	0.8	200		5
February 4, 1970								
0000	1.3	195	0.4	285	1.2	205		15
0030	1.4	215	0.6	280	1.3	215		35
0100	1.5	225	0.6	290	1.3	220		165
0130	1.7	235	0.5	275	1.0	235		185
0200	1.3	260	0.5	225	1.0	245		150
0230	1.2	265	0.6	165	1.0	245		150
0300	1.0	260	0.7	155	0.9	245		135
0330	0.8	255	0.7	150	0.8	245		110
0400	1.0	195	0.8	145	0.4	240		90
0430	0.8	185	0.8	145	0.3	205		75
0500	1.0	175	0.8	135	0.5	185		15
0530	1.1	175	0.7	135	0.5	105		15
0600	1.6	155	0.6	125	1.0	60		25
0630	1.7	150	0.6	125	1.6	45		35
0700	1.7	145	0.6	115	1.8	35		25

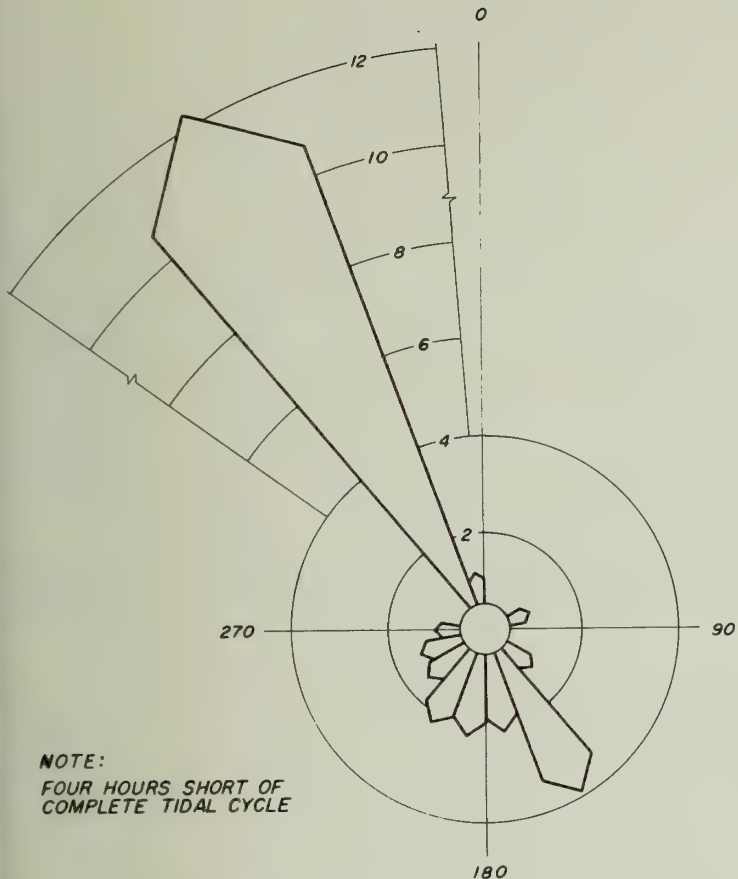
Continued on next page

Table 1. Continued

Station:	97		98		99		99	
Reference figure:	4-12		4-12		4-12		4-12	
Water depth, feet:	40		40		75		75	
Meter depth, feet:	15		15		15		60	
Time, PST	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
February 4, 1970 (continued)								
0730			0.6	125	1.8	55		10
0800			0.6	130	1.6	65		10
0830			0.5	140				
0900			0.5	195				
0930			0.5	215				

[a]Direction of movement in degrees measured clockwise from true north.

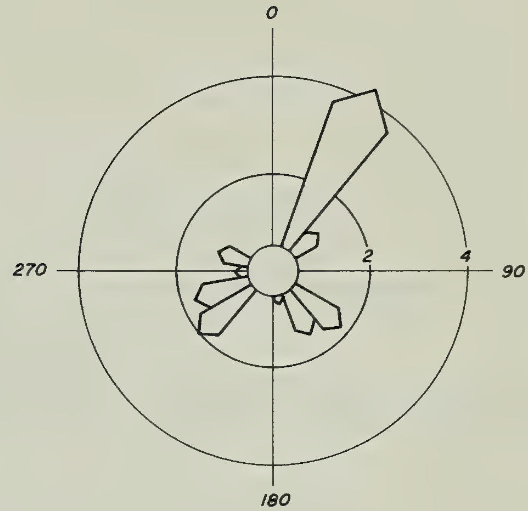
ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



NOTE:
FOUR HOURS SHORT OF COMPLETE TIDAL CYCLE

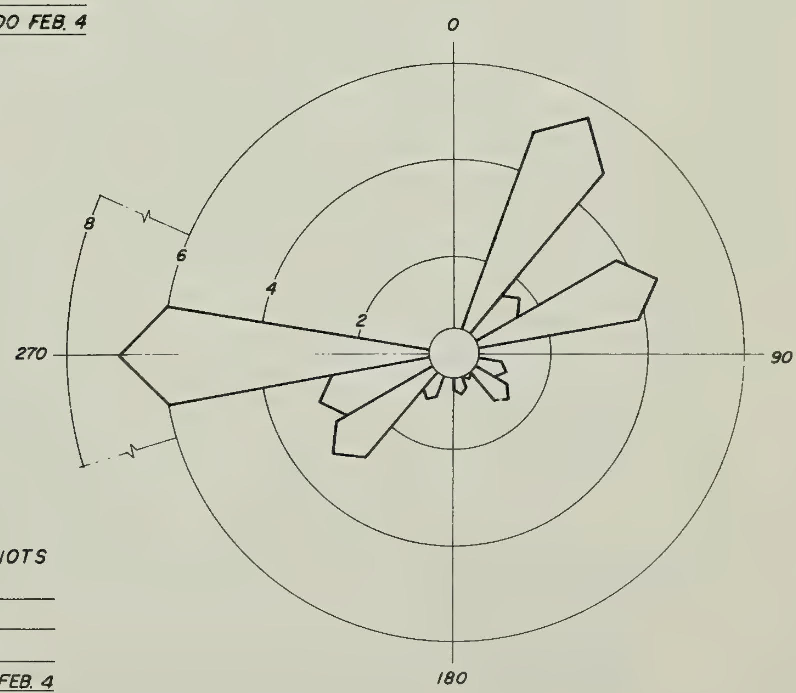
STATION	97	CURRENT, KNOTS	
DEPTH, FT	15	MAX.	2.27
DATE	FEB 3-4, 1970	MEAN	1.33
REFERENCE FIG.	4-12	MIN.	0.87

PERIOD OF OBSERVATION 1030 FEB. 3-0700 FEB. 4



STATION	98	CURRENT, KNOTS	
DEPTH, FT	15	MAX.	0.87
DATE	FEB. 3-4, 1970	MEAN	0.66
REFERENCE FIG.	4-12	MIN.	0.40

PERIOD OF OBSERVATION 0900 FEB. 3-0930 FEB. 4



STATION	99	CURRENT, KNOTS	
DEPTH, FT	15	MAX.	2.03
DATE	FEB. 3-4, 1970	MEAN	1.25
REFERENCE FIG.	4-12	MIN.	0.47

PERIOD OF OBSERVATION 0830 FEB. 3-0800 FEB. 4

Gulf of the Farallones Currents Summer Upwelling Season

Table 2. Summer Current Data, Gulf of the Farallones

Dates collected: June 17, 18, 19, 1970

Meter type: Tsurumi TSK E-2 Current Meter

Station: X
Reference figure: 4-19
Water depth, feet: 60
Date: 6-17-70
Time, PDST: 0733

Meter depth, feet	Speed, knots	Direction[a]
0	0.81	325
10	0.94	335
20	1.25	330
30	1.28	325
40	1.23	325
50	1.21	325

Station: X
Reference figure: 4-20
Water depth, feet: 60
Date: 6-18-70
Time, PDST: 1045

Meter depth, feet	Speed, knots	Direction[a]
0	1.73	015
10	1.41	015
20	1.47	015
30	1.20	015
40	1.19	015
50	1.19	015

Station: X
Reference figure: 4-20
Water depth, feet: 60
Date: 6-18-70
Time, PDST: 1700

Meter depth, feet	Speed, knots	Direction[a]
0	1.24	165
10	1.23	195
20	1.17	175
30	1.01	155
40	0.86	170
50	0.76	135

Station: Vicinity X
Reference figure: 4-20
Water depth, feet: 40
Date: 6-18-70
Time, PDST: 1809

Meter depth, feet	Speed, knots	Direction[a]
0	0.35	175
10	0.33	070
20	0.34	255
28	0.36	025
35	0.38	015

Station: Vicinity X
Reference figure: 4-20
Water depth, feet: 90
Date: 6-18-70
Time, PDST: 1912

Meter depth, feet	Speed, knots	Direction[a]
0	0.53	015
10	0.84	015
20	0.79	015
30	0.81	050
40	0.94	035
50	1.22	045
60	1.35	035
70	1.45	035
80	1.18	015

Station: X
Reference figure: 4-20
Water depth, feet: 60
Date: 6-19-70
Time, PDST: 0233

Meter depth, feet	Speed, knots	Direction[a]
0	2.18	195
10	2.37	175
20	2.22	185
30	2.12	195
40	2.06	200
50	0.40	.195

[a] Direction of movement in degrees measured clockwise from true north.

Continued on next page

Table 2. Continued

Dates collected: June 17, 18, 19, 1970

Meter type: Tsurumi TSK E-2 Current Meter

Station: Vicinity X Reference figure: 4-20 Water depth, feet: 30 Date: 6-19-70 Time, PDST: 0423			Station: Vicinity X Reference figure: 4-20 Water depth, feet: 80 Date: 6-19-70 Time, PDST: 0535		
Meter depth, feet	Speed, knots	Direction[a]	Meter depth, feet	Speed, knots	Direction[a]
0	1.46	Direction indicator failed	0	0.35	Direction indicator failed
6	1.02		10	0.56	
12	1.05		20	0.30	
18	1.20		30	0.21	
24	0.76		40	Velocity indicator failed	

Station: Y Reference figure: 4-19 Water depth, feet: 90 Date: 6-17-70 Time, PDST: 1258			Station: Y Reference figure: 4-20 Water depth, feet: 90 Date: 6-18-70 Time, PDST: 1337		
Meter depth, feet	Speed, knots	Direction[a]	Meter depth, feet	Speed, knots	Direction[a]
0	0.46	015	0	0.40	015
10	0.41	025	10	0.35	015
20	0.42	270	20	0.36	015
30	0.55	245	30	0.29	015
40	0.50	235	40	0.27	015
50	0.45	225	50	0.44	255
60	0.41	205	60	0.30	Unknown
70	0.46	225	70	0.55	235
80	0.54	205	80	0.35	225

Station: Vicinity Y Reference figure: 4-20 Water depth, feet: 70 Date: 6-18-70 Time, PDST: 1438			Station: Vicinity Y Reference figure: 4-20 Water depth, feet: 90 Date: 6-18-70 Time, PDST: 1533		
Meter depth, feet	Speed, knots	Direction[a]	Meter depth, feet	Speed, knots	Direction[a]
0	0.41	165	0	0.37	015
10	0.48	205	10	0.31	015
20	0.33	165	20	0.32	015
30	0.37	185	30	0.32	015
40	0.35	165	40	0.33	355
50	0.38	195	50	0.55	245
60	0.32	195	60	0.46	255
			70	0.47	255
			80	0.36	265

[a]Direction of movement in degrees measured clockwise from true north.

Continued on next page

Table 2. Continued

Dates collected: June 17, 18, 19, 1970

Meter type: Tsurumi TSK E-2 Current Meter

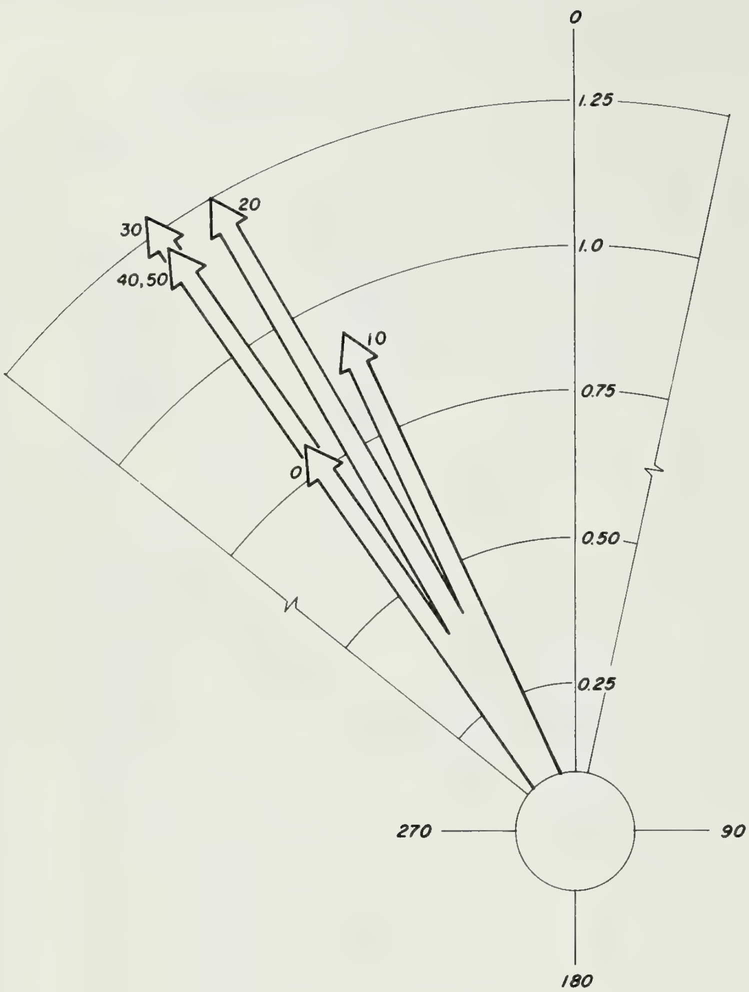
Station: Y Reference figure: 4-20 Water depth, feet: 90 Date: 6-18-70 Time, PDST: 2115			Station: Vicinity Y Reference figure: 4-20 Water depth, feet: 85 Date: 6-18-70 Time, PDST: 2258		
Meter depth, feet	Speed, knots	Direction[a]	Meter depth, feet	Speed, knots	Direction[a]
0	0.47	095	0	0.35	Direction indicator failed
10	0.41	015	10	0.44	
20	0.43	345	20	0.34	
30	0.42	015	30	0.41	
40	0.43	015	40	0.42	
50	0.29	015	50	0.33	
60	0.57	015	60	0.34	
70	0.48	015	70	0.46	
80	0.43	015	80	0.33	

Station: Vicinity Y Reference figure: 4-20 Water depth, feet: 90 Date: 6-19-70 Time, PDST: 0003		
Meter depth, feet	Speed, knots	Direction[a]
0	0.53	135
10	0.48	Direction indicator failed
20	0.60	
30	0.56	
40	0.62	
50	0.50	
60	0.63	
70	0.55	
80	0.52	

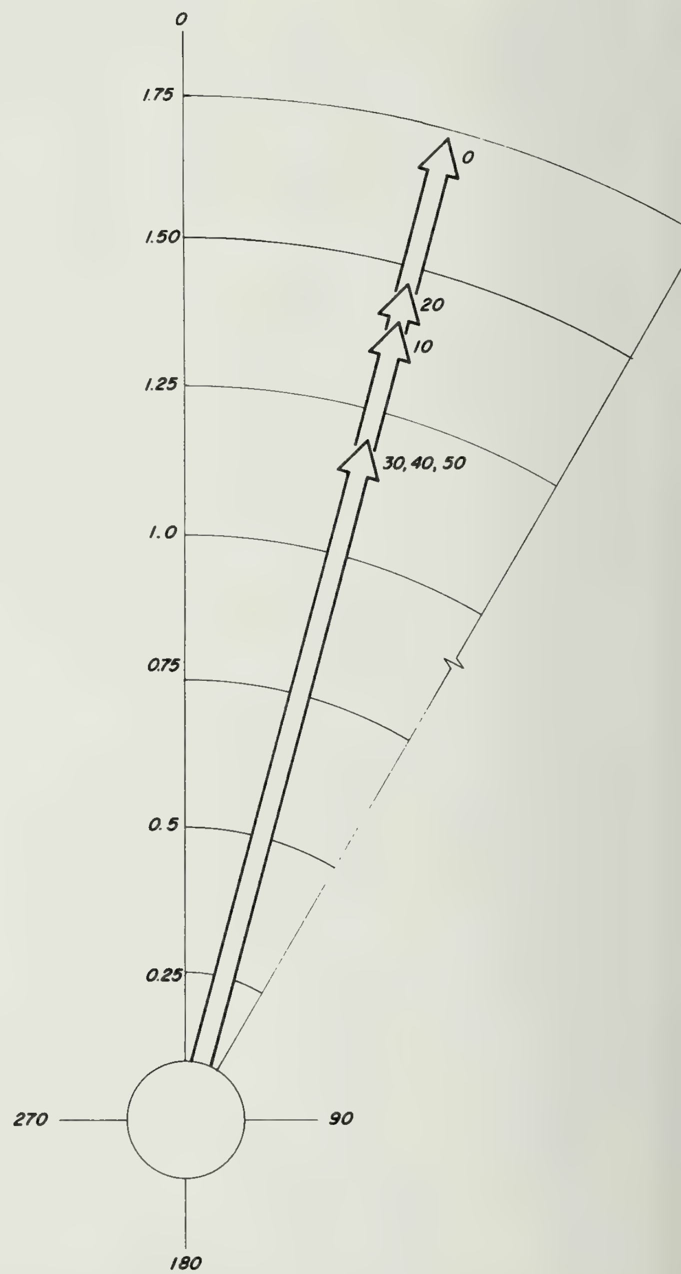
[a]Direction of movement in degrees measured clockwise from true north.

VARIATION IN CURRENT DIRECTION AND
VELOCITY WITH DEPTH

VELOCITY IN KNOTS   DEPTH IN FEET



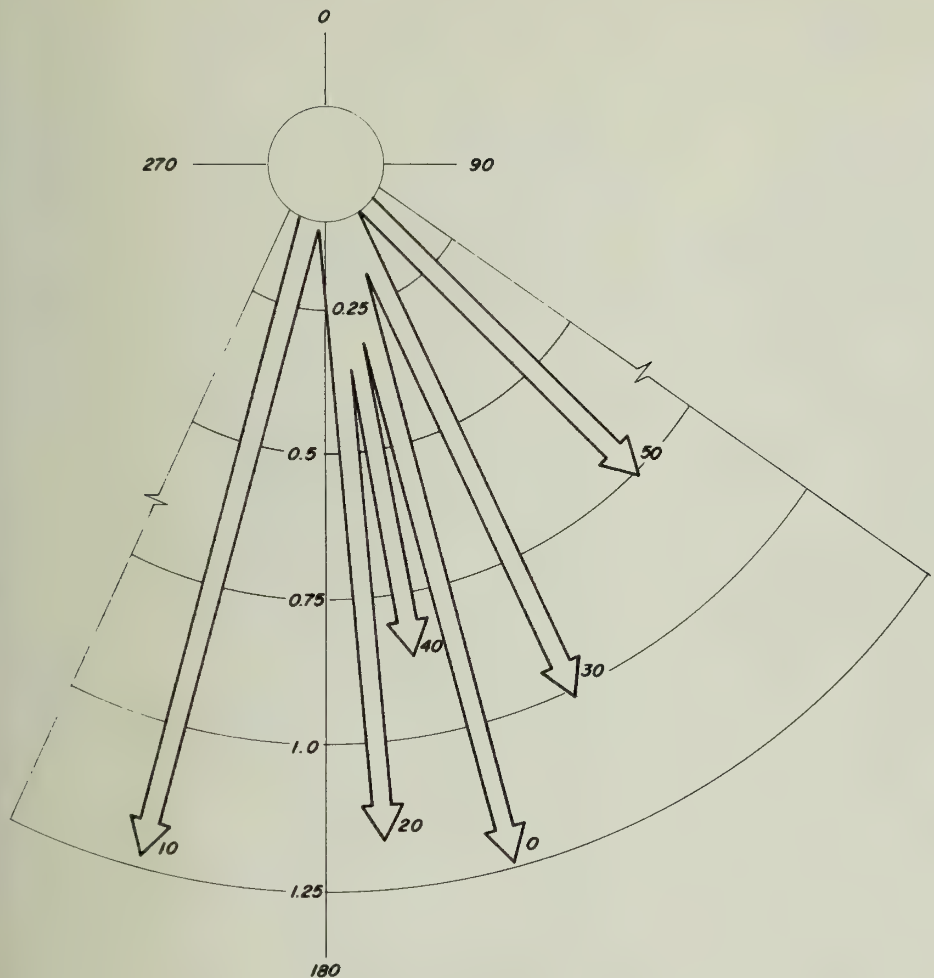
STATION X   DATE 6/17/70
TOTAL DEPTH 60 FT.   TIME 0733 HRS.
REFERENCE FIG. 4-19



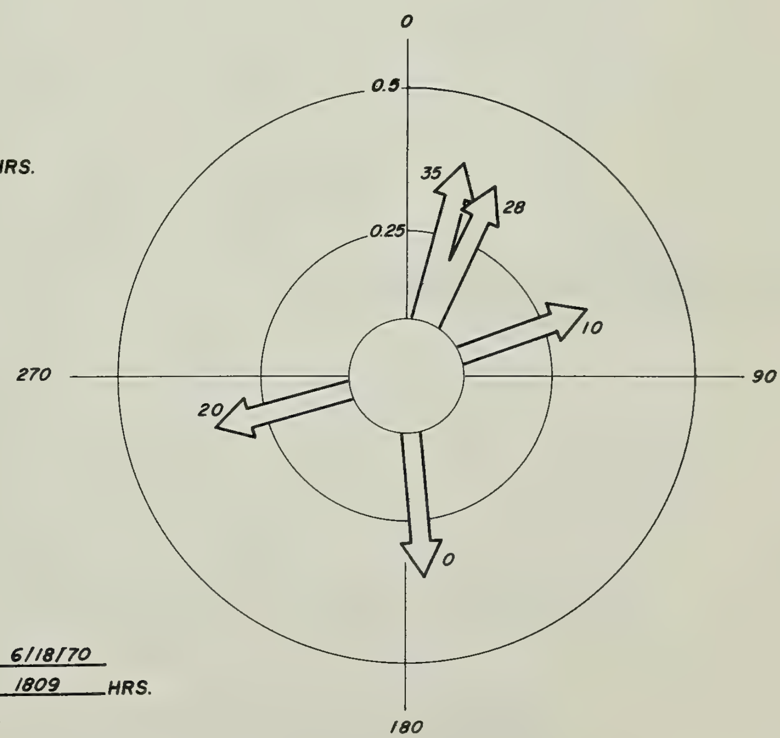
STATION X   DATE 6/18/70
TOTAL DEPTH 60 FT.   TIME 1045 HRS.
REFERENCE FIG. 4-20

VARIATION IN CURRENT DIRECTION AND
VELOCITY WITH DEPTH

VELOCITY IN KNOTS · DEPTH IN FEET



STATION ___X___ DATE 6/18/70
TOTAL DEPTH 60 FT. TIME 1700 HRS.
REFERENCE FIG. 4-20

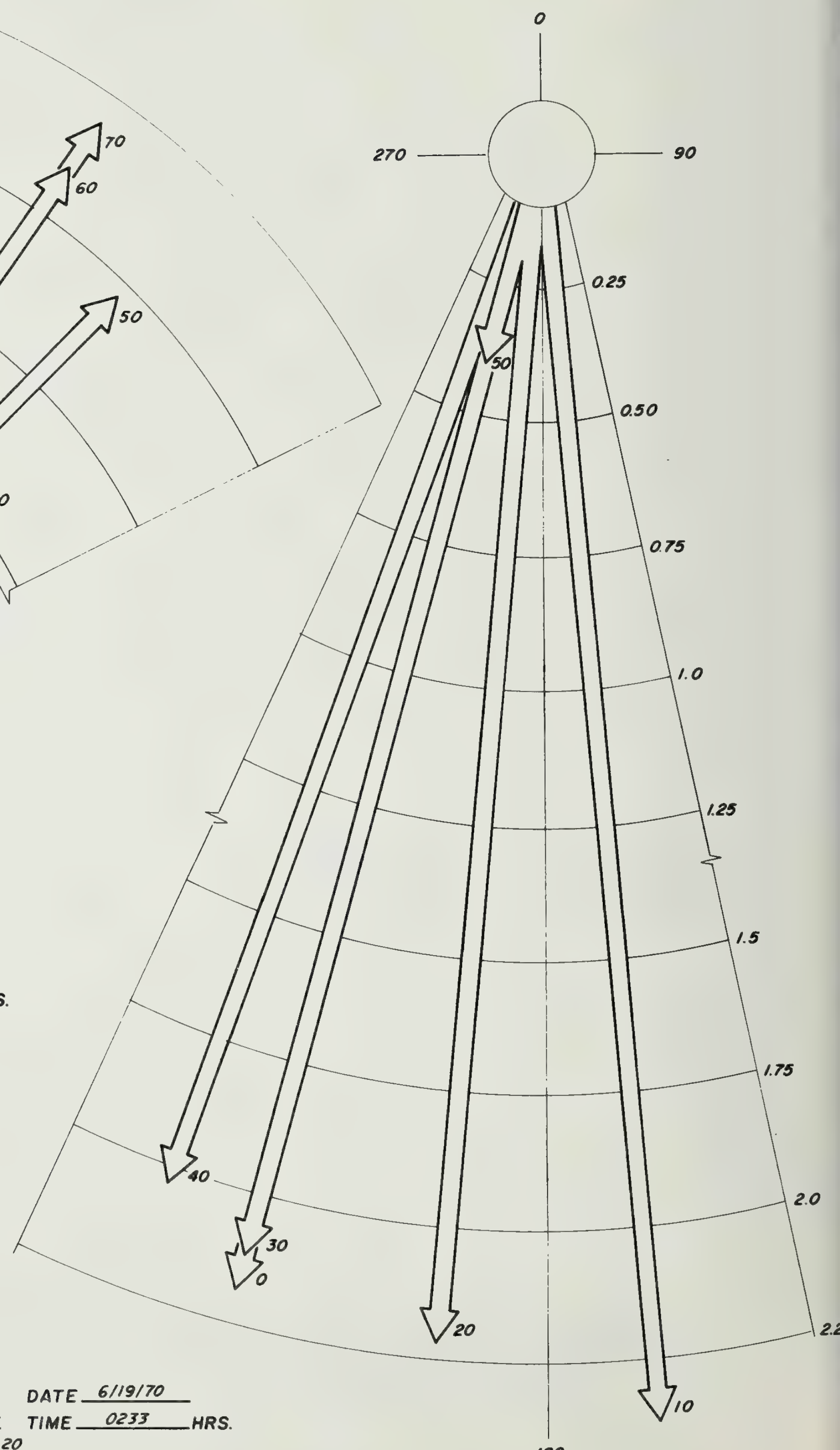


STATION VICINITY X DATE 6/18/70
TOTAL DEPTH 40 FT. TIME 1809 HRS.
REFERENCE FIG. 4-20

VARIATION IN CURRENT DIRECTION AND
VELOCITY WITH DEPTH

VELOCITY IN KNOTS   DEPTH IN FEET

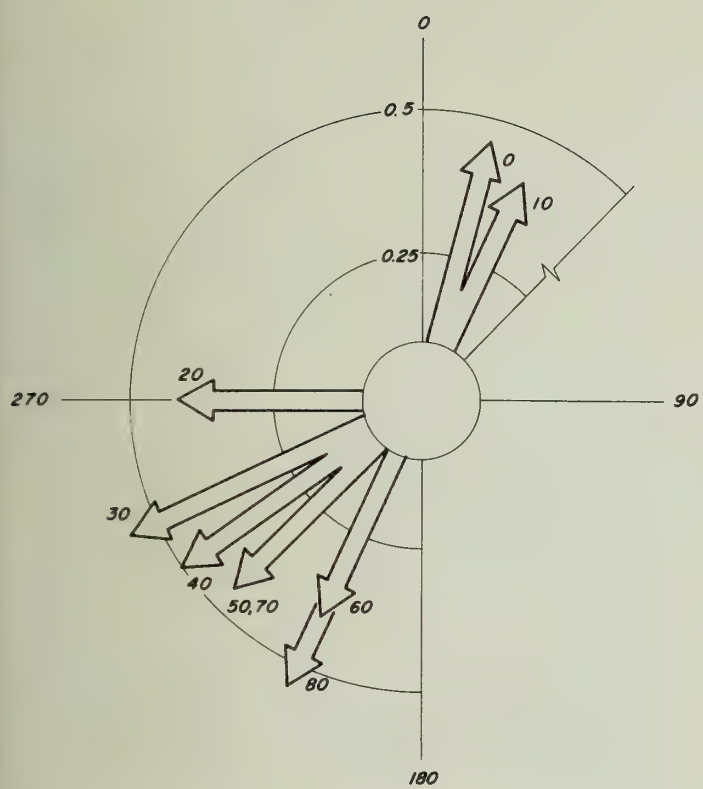
STATION VICINITY X   DATE 6/18/70
TOTAL DEPTH 90 FT.   TIME 1912 HRS.
REFERENCE FIG. 4-20



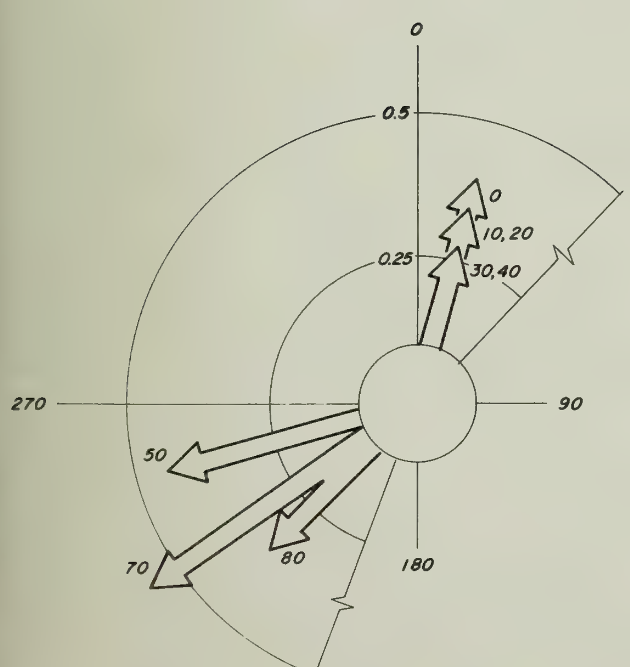
STATION X   DATE 6/19/70
TOTAL DEPTH 60 FT.   TIME 0233 HRS.
REFERENCE FIG. 4-20

VARIATION IN CURRENT DIRECTION AND
VELOCITY WITH DEPTH

VELOCITY IN KNOTS   DEPTH IN FEET



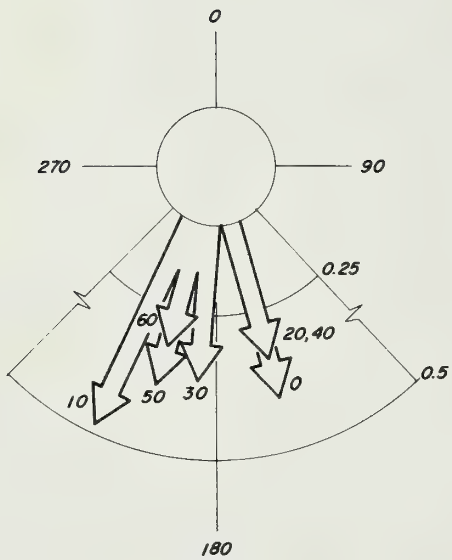
STATION Y   DATE 6/17/70
TOTAL DEPTH 90 FT. TIME 1258 HRS.
REFERENCE FIG. 4-19



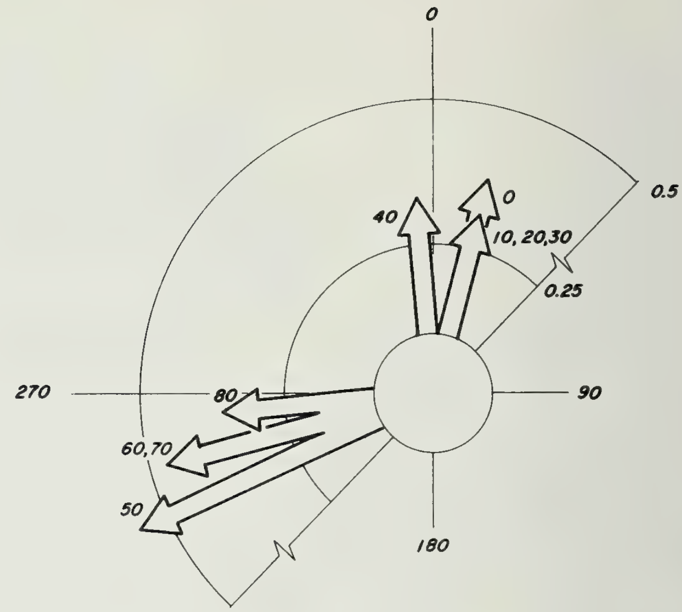
STATION Y   DATE 6/18/70
TOTAL DEPTH 90 FT. TIME 1337 HRS.
REFERENCE FIG. 4-20

VARIATION IN CURRENT DIRECTION AND
VELOCITY WITH DEPTH

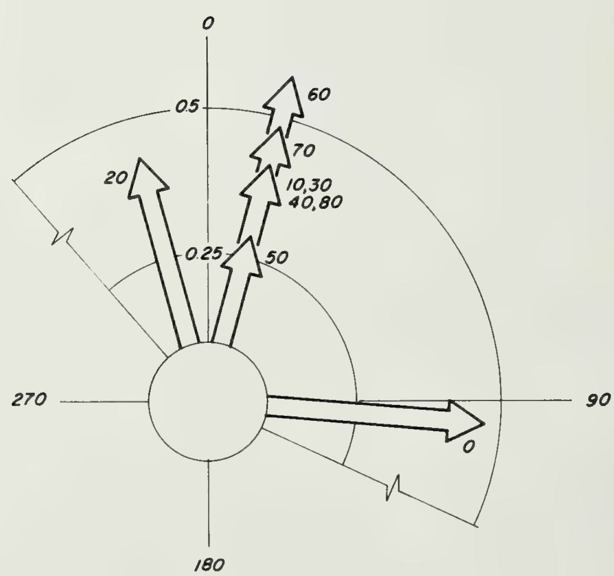
VELOCITY IN KNOTS   DEPTH IN FEET



STATION VICINITY Y   DATE 6/18/70
TOTAL DEPTH 70 FT.   TIME 1438 HRS.
REFERENCE FIG. 4-20

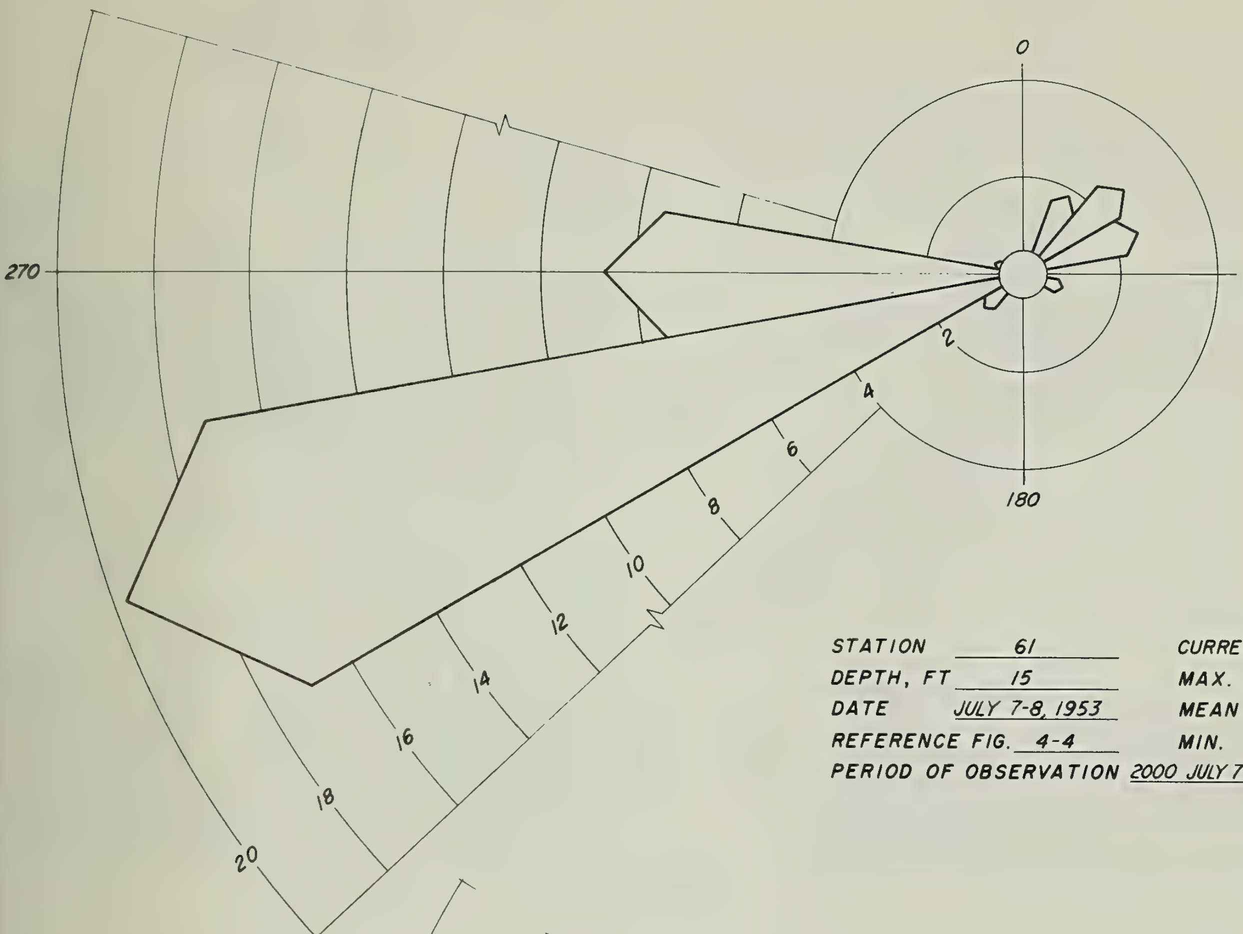


STATION VICINITY Y   DATE 6/18/70
TOTAL DEPTH 90 FT.   TIME 1533 HRS.
REFERENCE FIG. 4-20

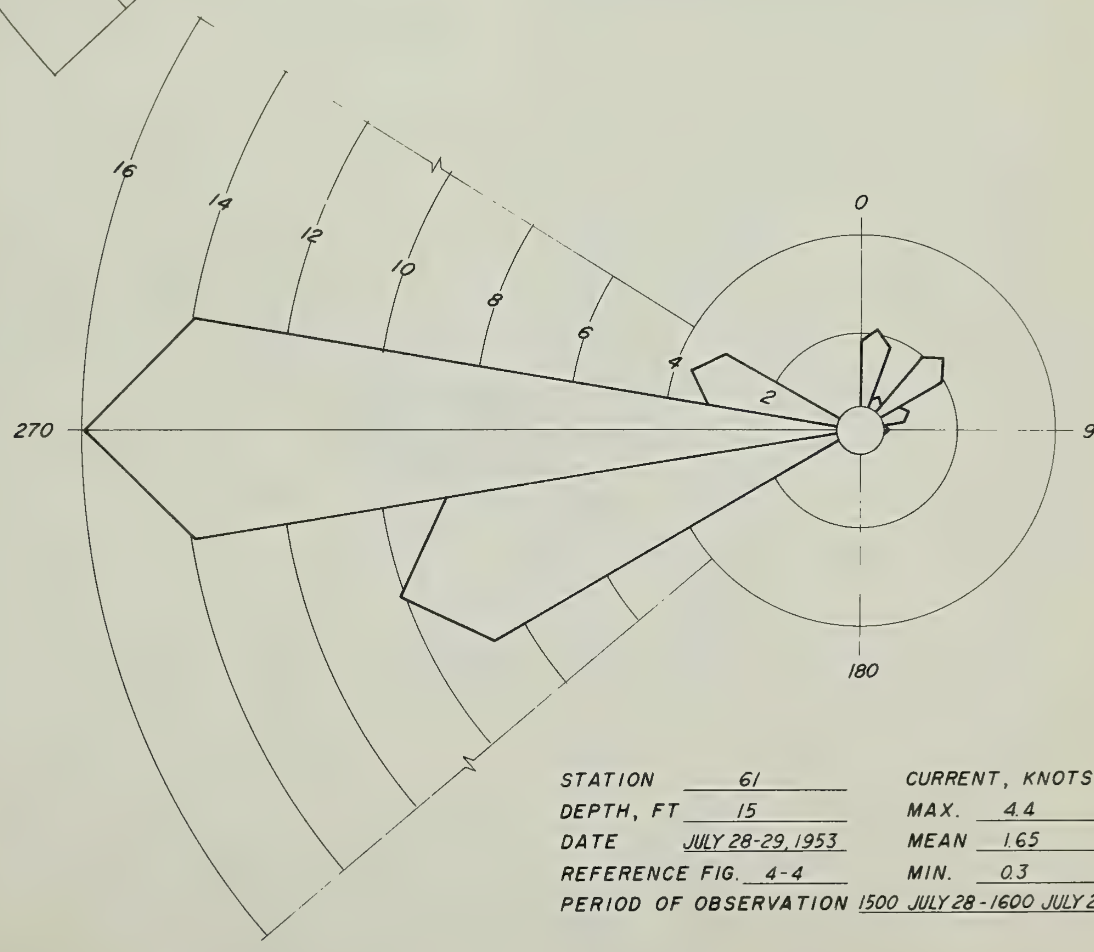


STATION Y   DATE 6/18/70
TOTAL DEPTH 90 FT.   TIME 2115 HRS.
REFERENCE FIG. 4-20

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)

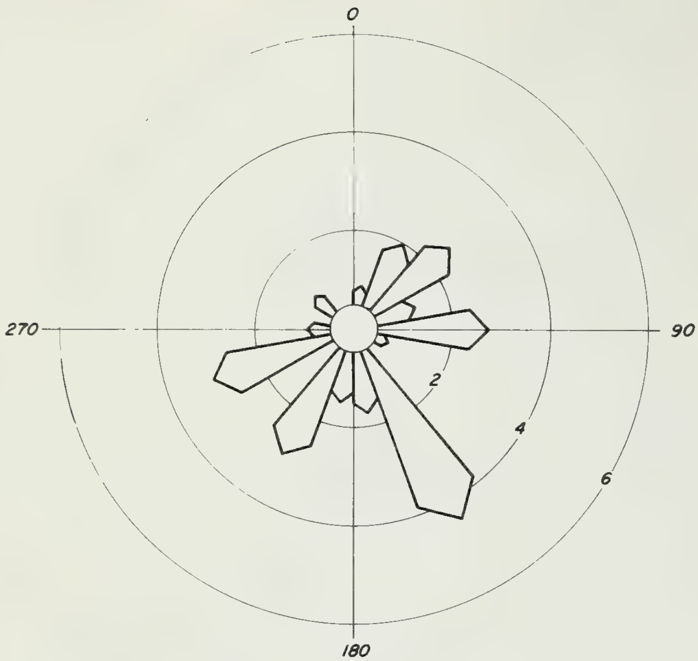


STATION	61	CURRENT, KNOTS	
DEPTH, FT	15	MAX.	4.4
DATE	JULY 7-8, 1953	MEAN	1.55
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	2000 JULY 7 - 2100 JULY 8		

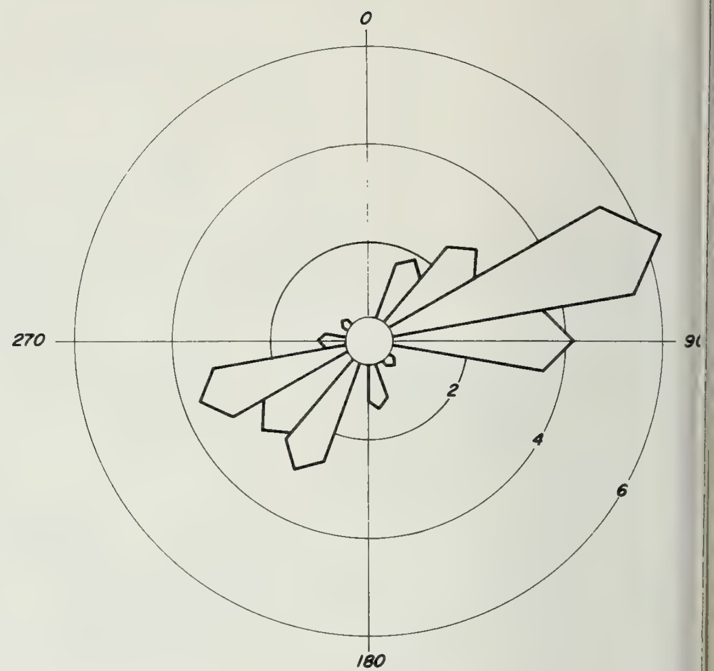


STATION	61	CURRENT, KNOTS	
DEPTH, FT	15	MAX.	4.4
DATE	JULY 28-29, 1953	MEAN	1.65
REFERENCE FIG.	4-4	MIN.	0.3
PERIOD OF OBSERVATION	1500 JULY 28 - 1600 JULY 29		

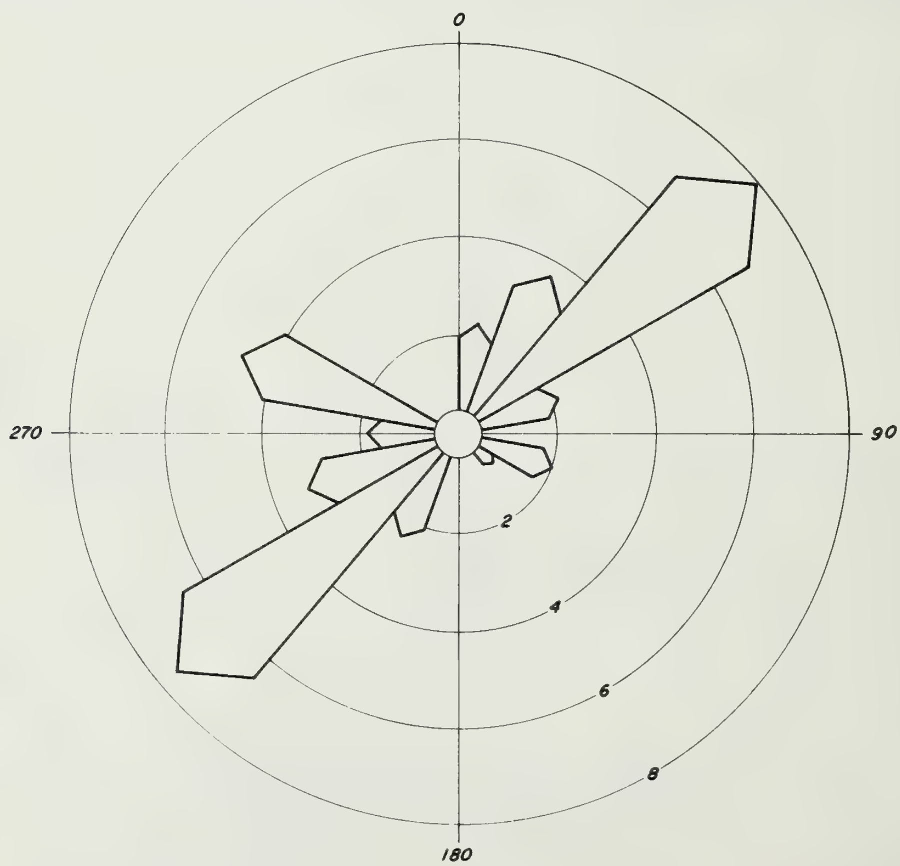
ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 64 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 1.9
DATE AUG. 20-21, 1953 — MEAN 1.03
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 2200 AUG. 20-2300 AUG. 21



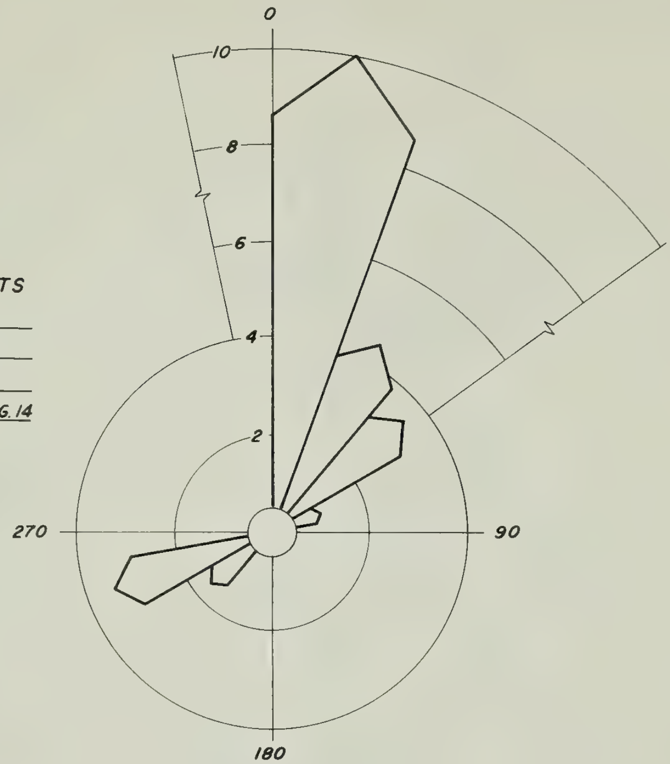
STATION 64 — CURRENT, KNOTS
DEPTH, FT 51 — MAX. 2.1
DATE AUG. 20-21, 1953 — MEAN 1.15
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 2200 AUG. 20-2300 AUG. 21



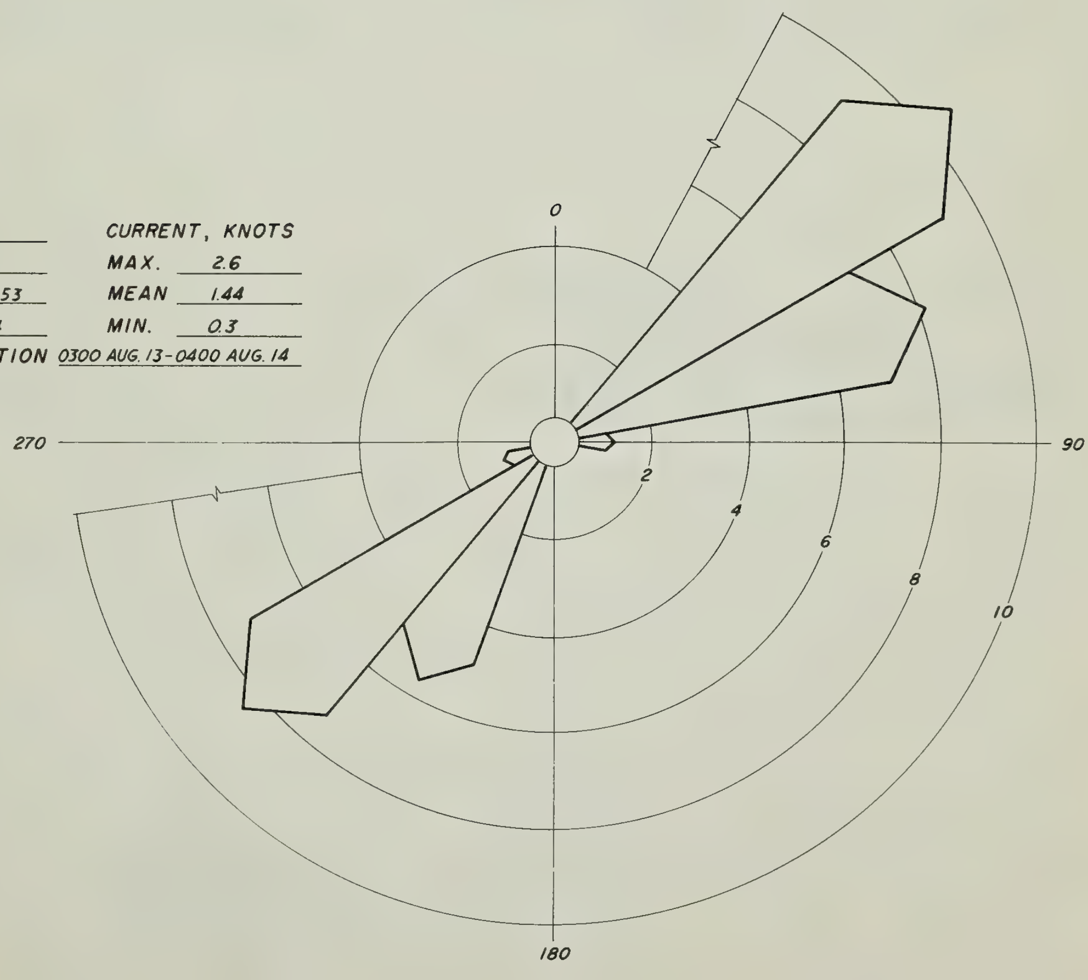
STATION 64 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 3.3
DATE AUG. 27-28, 1953 — MEAN 1.55
REFERENCE FIG. 4-4 — MIN. 0.3
PERIOD OF OBSERVATION 0300 AUG. 27-0400 AUG. 28

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)

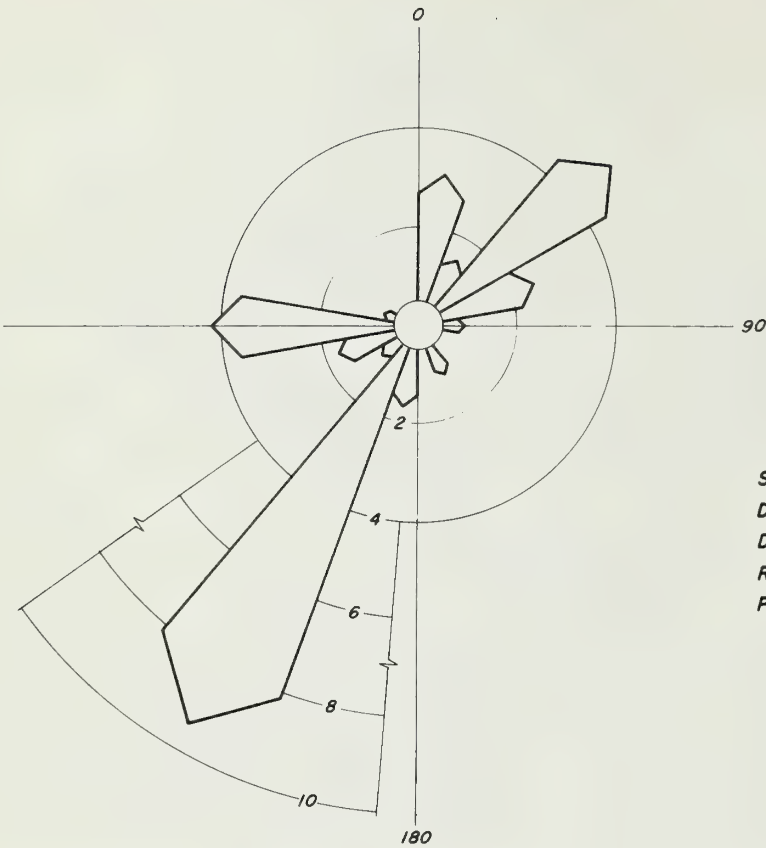
STATION	65	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.8
DATE	AUG. 13-14, 1953	MEAN	1.55
REFERENCE FIG.	4-4	MIN.	0.3
PERIOD OF OBSERVATION	0300 AUG. 13-0400 AUG. 14		



STATION	65	CURRENT, KNOTS	
DEPTH, FT	45	MAX.	2.6
DATE	AUG. 13-14, 1953	MEAN	1.44
REFERENCE FIG.	4-4	MIN.	0.3
PERIOD OF OBSERVATION	0300 AUG. 13-0400 AUG. 14		



ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)

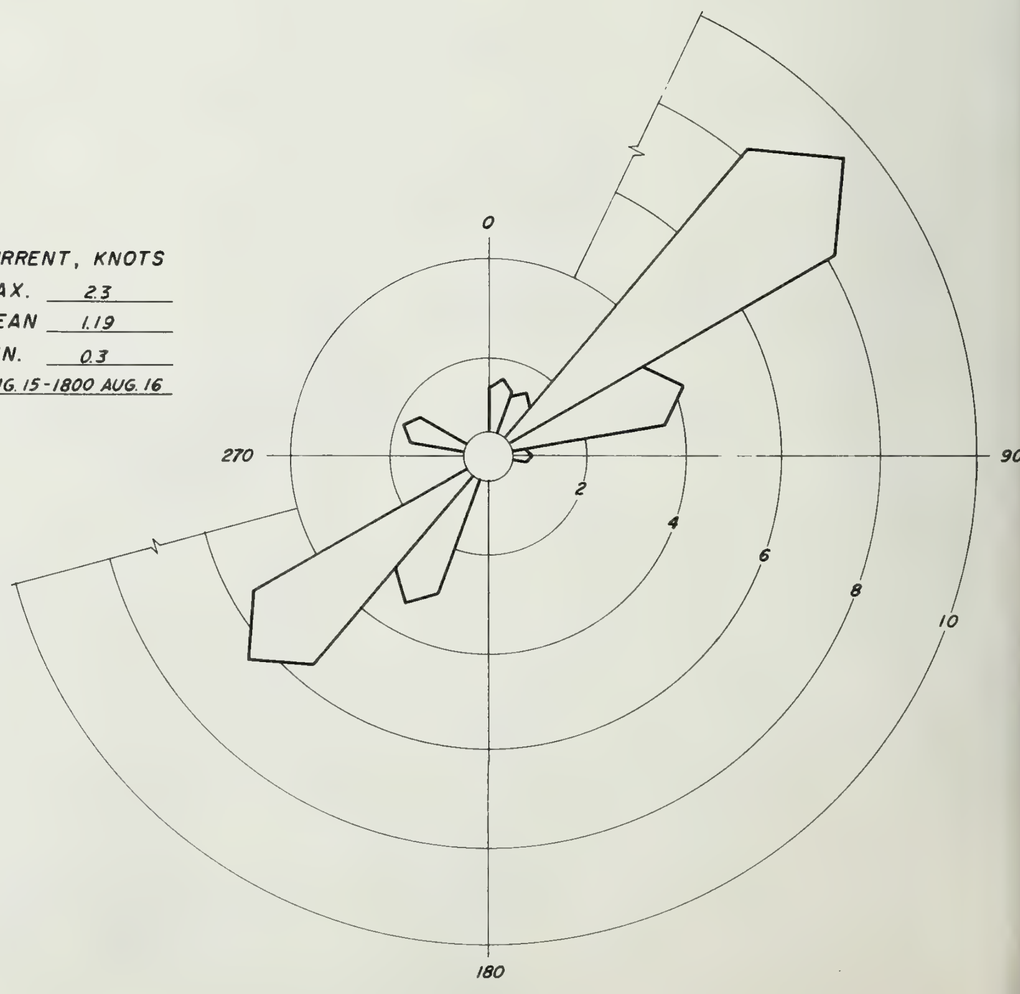


STATION	65	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.6
DATE	AUG. 15-16, 1953	MEAN	1.31
REFERENCE FIG.	4-4	MIN.	0.3

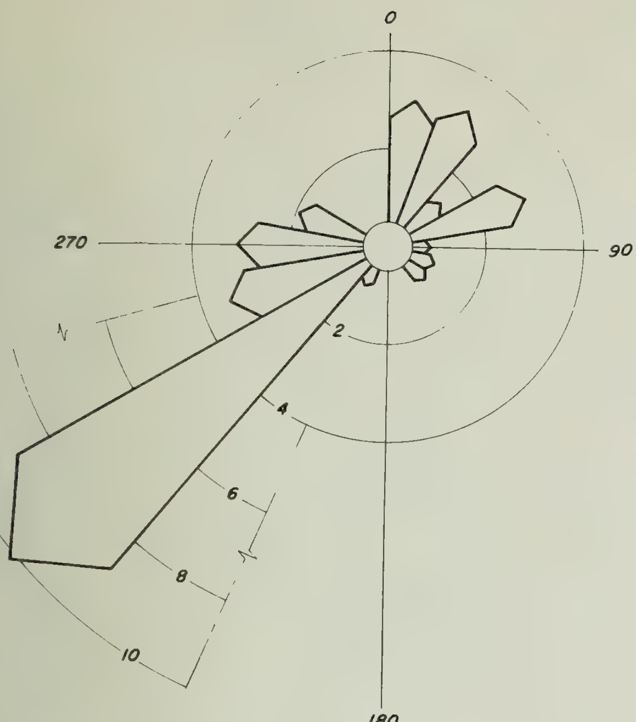
PERIOD OF OBSERVATION 1700 AUG. 15-1800 AUG. 16

STATION	65	CURRENT, KNOTS	
DEPTH, FT	45	MAX.	2.3
DATE	AUG. 15-16, 1953	MEAN	1.19
REFERENCE FIG.	4-4	MIN.	0.3

PERIOD OF OBSERVATION 1700 AUG. 15-1800 AUG. 16

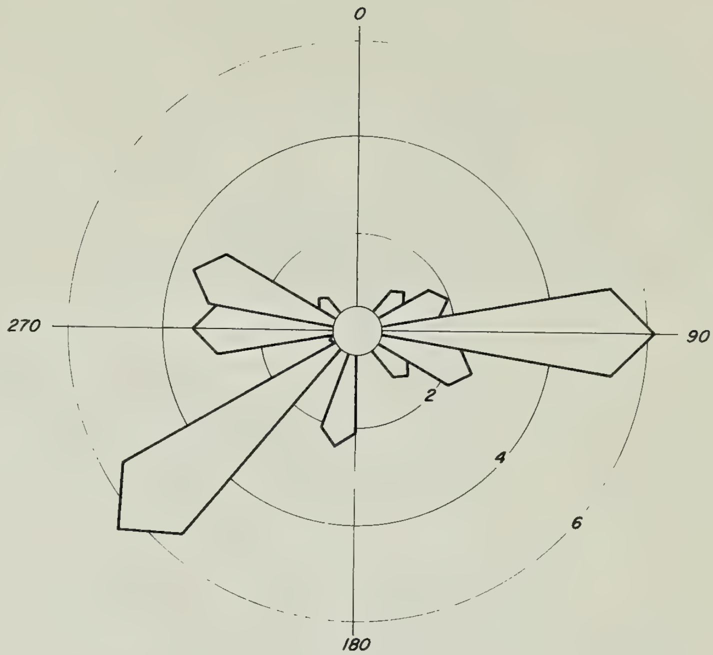


ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



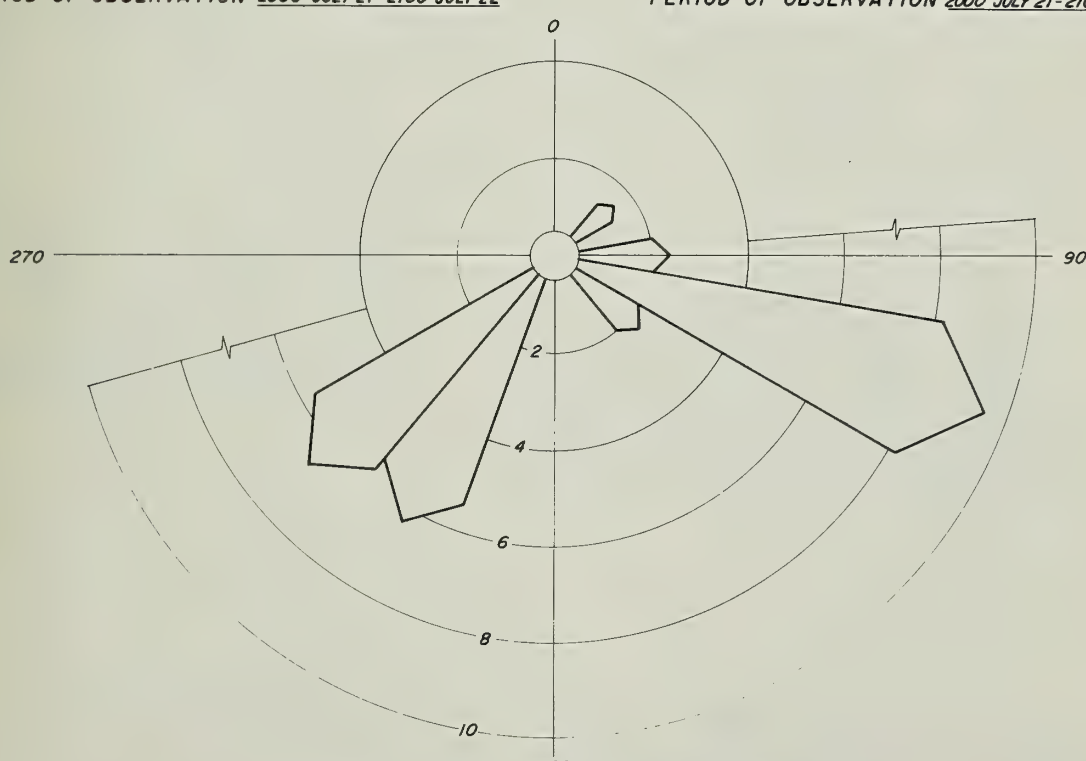
STATION 66
DEPTH, FT 8
DATE JULY 21-22, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 2000 JULY 21-2100 JULY 22

CURRENT, KNOTS
MAX. 2.6
MEAN 1.34
MIN. 0.2



STATION 66
DEPTH, FT 41
DATE JULY 21-22, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 2000 JULY 21-2100 JULY 22

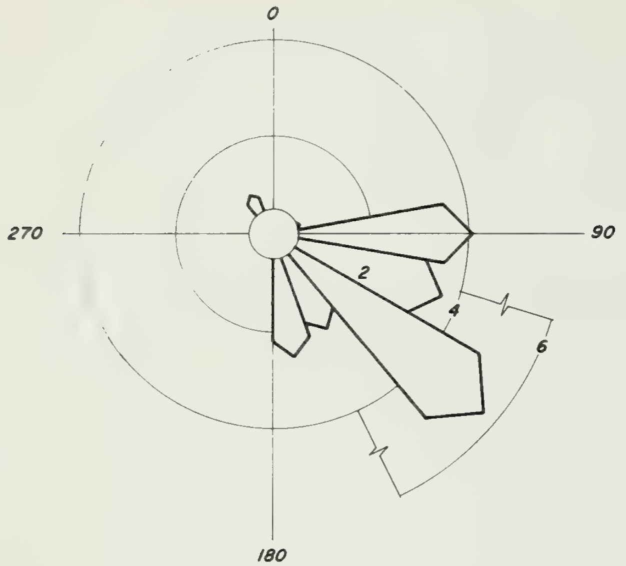
CURRENT, KNOTS
MAX. 2.5
MEAN 1.23
MIN. 0.2



STATION 66
DEPTH, FT 84
DATE JULY 21-22, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 2000 JULY 21-2100 JULY 22

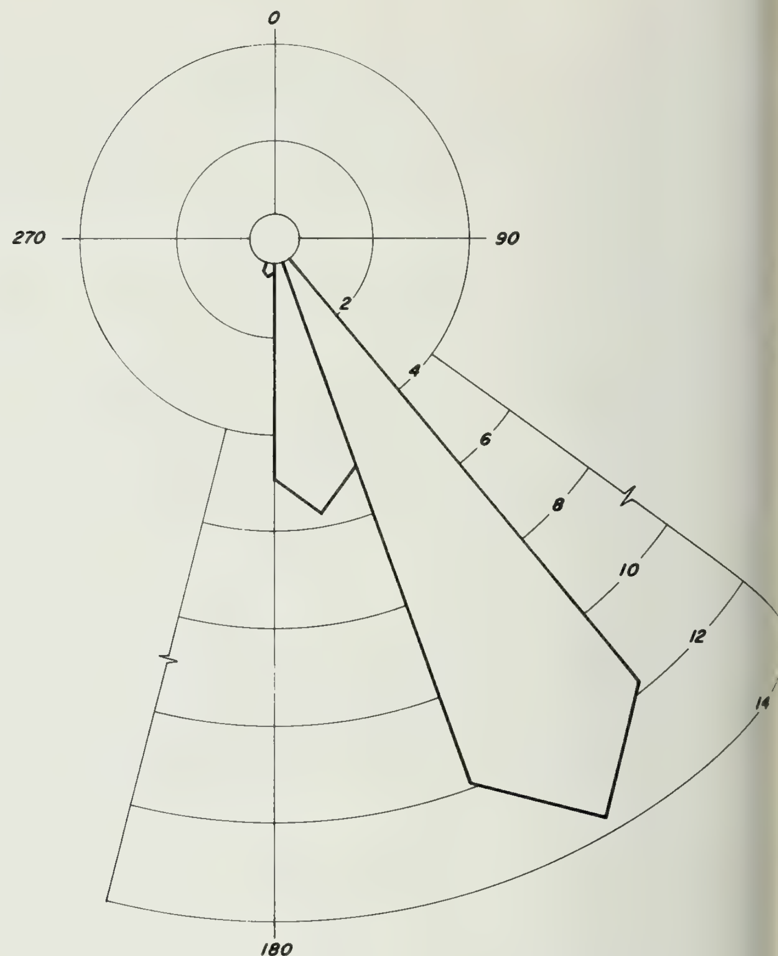
CURRENT, KNOTS
MAX. 2.6
MEAN 1.20
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



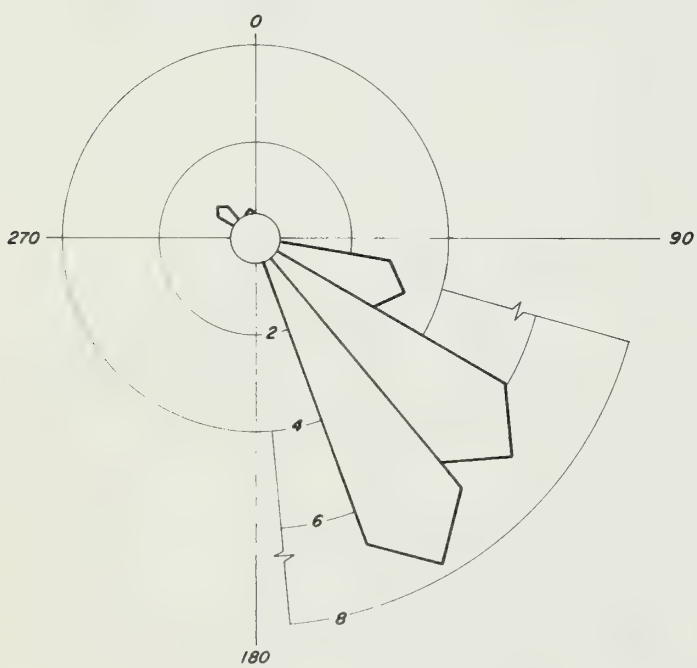
STATION 68
DEPTH, FT 8
DATE JULY 11-12, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0000 JULY 11-0100 JULY 12

CURRENT, KNOTS
MAX. 1.7
MEAN 0.85
MIN. 0.2



STATION 68
DEPTH, FT 33
DATE JULY 11-12, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0000 JULY 11-0100 JULY 12

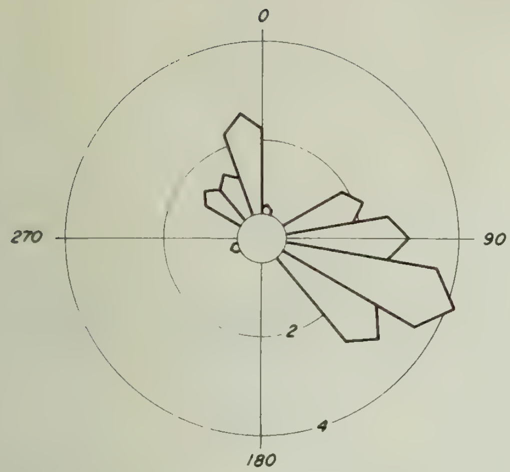
CURRENT, KNOTS
MAX. 2.0
MEAN 0.88
MIN. 0.3



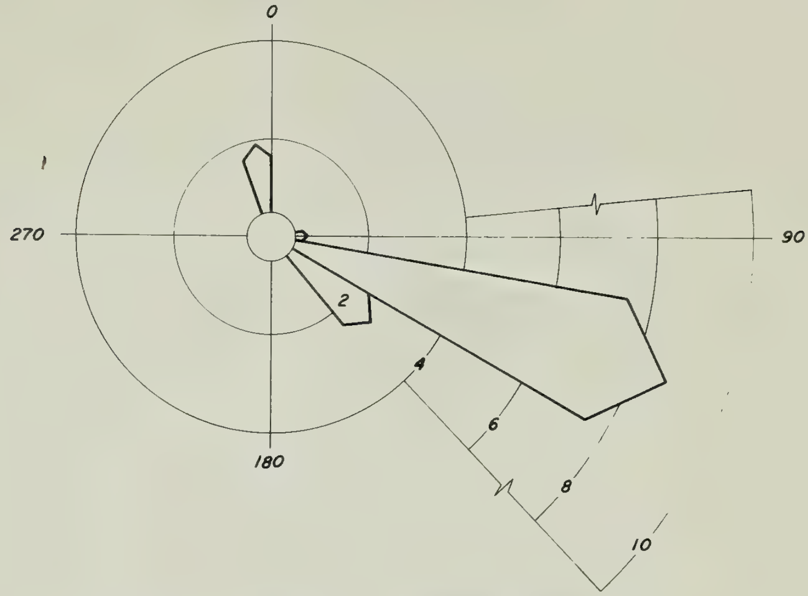
STATION 68
DEPTH, FT 58
DATE JULY 11-12, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0000 JULY 11-0100 JULY 12

CURRENT, KNOTS
MAX. 1.8
MEAN 0.83
MIN. 0.2

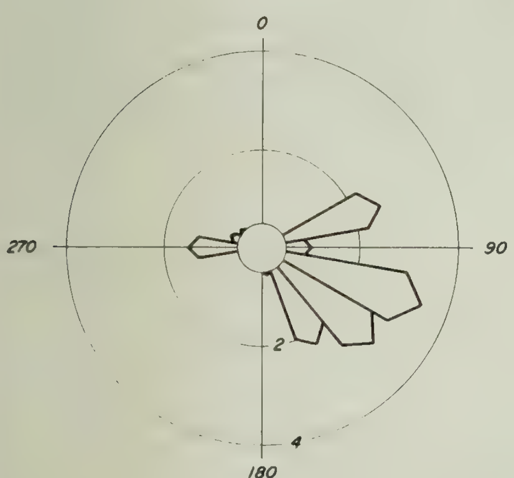
ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



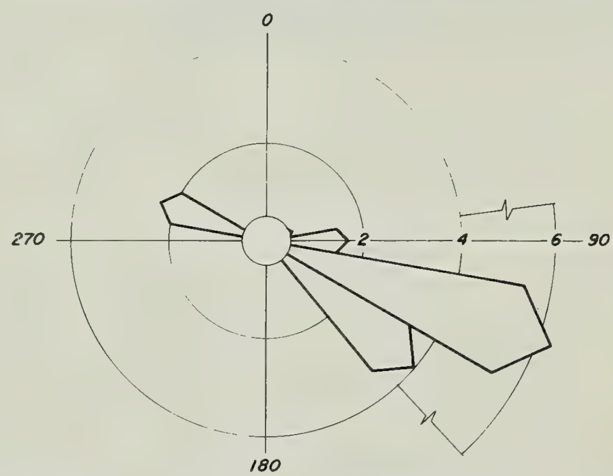
STATION 69 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 1.4
DATE JULY 31 - AUG. 1, 1953 — MEAN 0.79
REFERENCE FIG. 4-4 — MIN. 0.3
PERIOD OF OBSERVATION 0500 JULY 31-0600 AUG. 1



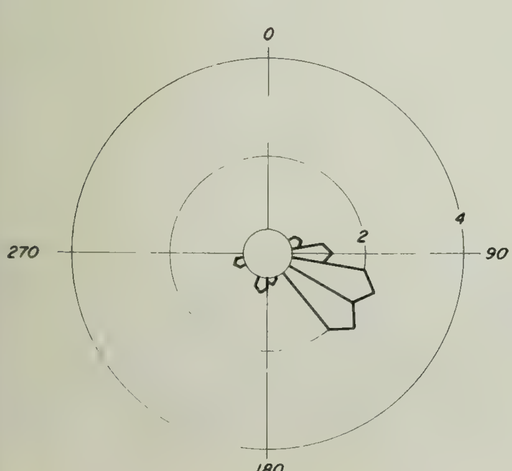
STATION 69 — CURRENT, KNOTS
DEPTH, FT 28 — MAX. 1.2
DATE JULY 31-AUG. 1, 1953 — MEAN 0.63
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 0500 JULY 31-0600 AUG. 1



STATION 69 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 1.1
DATE JULY 16-17, 1953 — MEAN 0.63
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 0400 JULY 16-0500 JULY 17

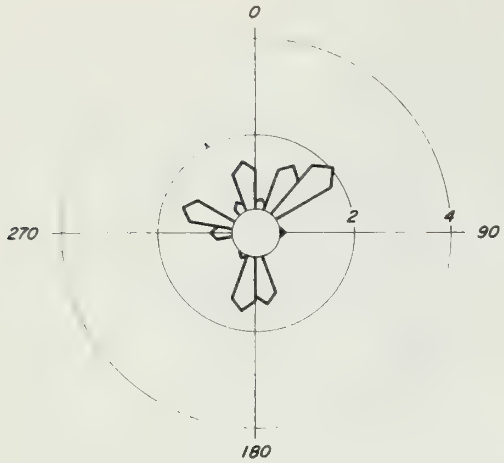


STATION 69 — CURRENT, KNOTS
DEPTH, FT 28 — MAX. 1.1
DATE JULY 16-17, 1953 — MEAN 0.66
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 0400 JULY 16-0500 JULY 17



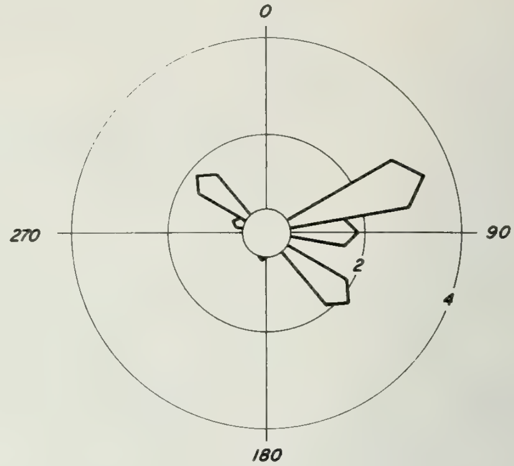
STATION 69 — CURRENT, KNOTS
DEPTH, FT 49 — MAX. 0.8
DATE JULY 16-17, 1953 — MEAN 0.42
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 0400 JULY 16-0500 JULY 17

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



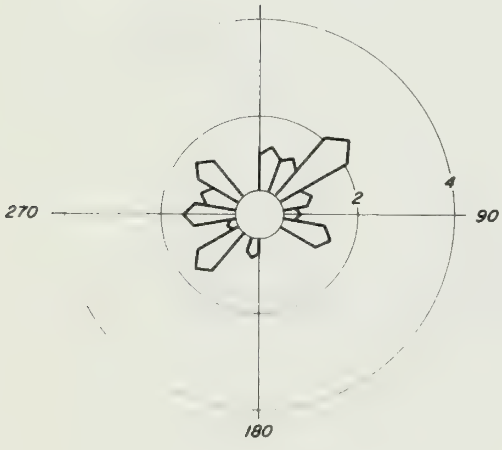
STATION 70
DEPTH, FT 8
DATE JULY 11-12, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0200 JULY 11-0300 JULY 12

CURRENT, KNOTS
MAX. 0.9
MEAN 0.57
MIN. 0.2



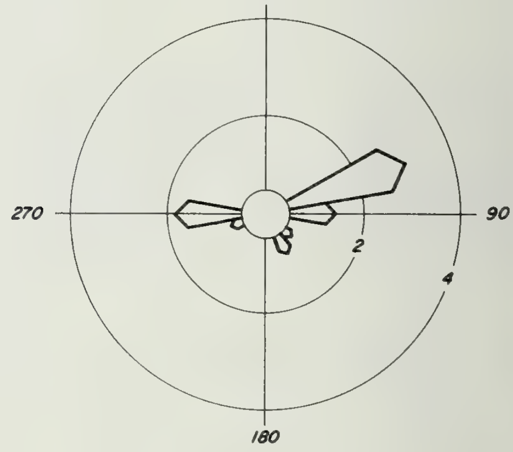
STATION 70
DEPTH, FT 27
DATE JULY 11-12, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0200 JULY 11-0300 JULY 12

CURRENT, KNOTS
MAX. 1.1
MEAN 0.51
MIN. 0.2



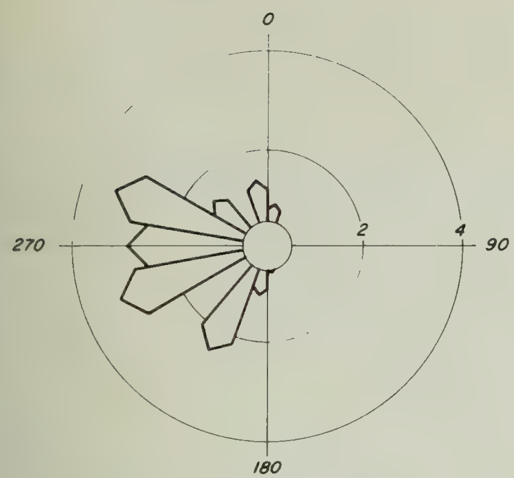
STATION 70
DEPTH, FT 8
DATE JULY 7-8, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1600 JULY 7-1700 JULY 8

CURRENT, KNOTS
MAX. 1.0
MEAN 0.66
MIN. 0.2

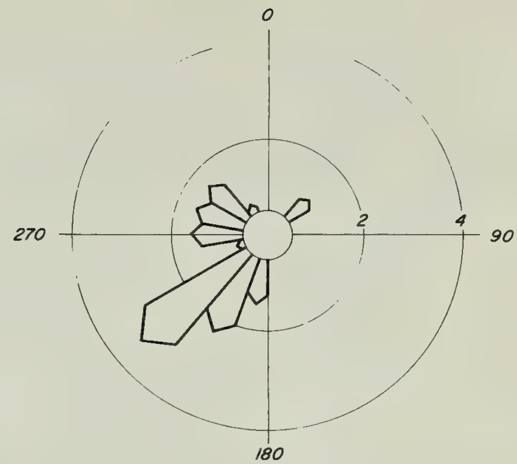


STATION 70
DEPTH, FT 27
DATE JULY 7-8, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1600 JULY 7-1700 JULY 8

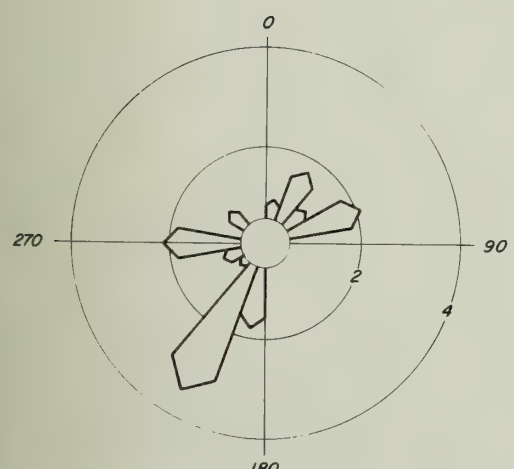
CURRENT, KNOTS
MAX. 1.0
MEAN 0.45
MIN. 0.2



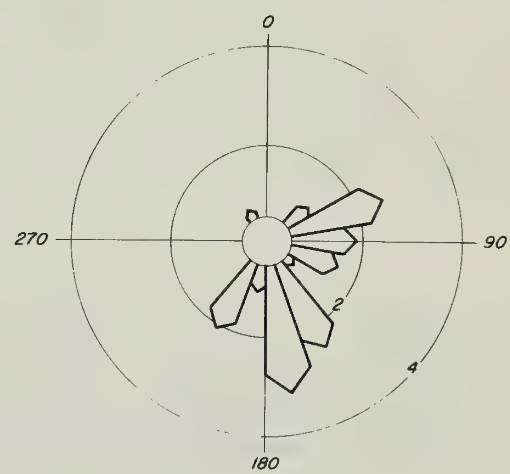
STATION 71 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 1.4
DATE JULY 17-18, 1953 — MEAN 0.70
REFERENCE FIG. 4-4 — MIN. 0.3
PERIOD OF OBSERVATION 0600 JULY 17-0700 JULY 18



STATION 71 — CURRENT, KNOTS
DEPTH, FT 33 — MAX. 1.0
DATE JULY 17-18, 1953 — MEAN 0.60
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 0600 JULY 17-0700 JULY 18

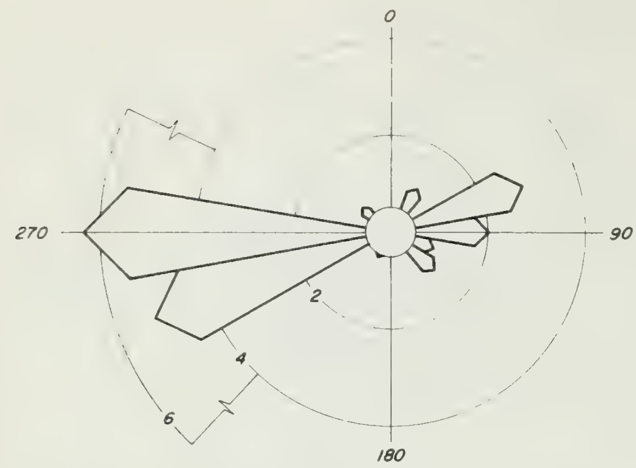


STATION 71 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 1.4
DATE JULY 14-15, 1953 — MEAN 0.62
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 0300 JULY 14-0400 JULY 15

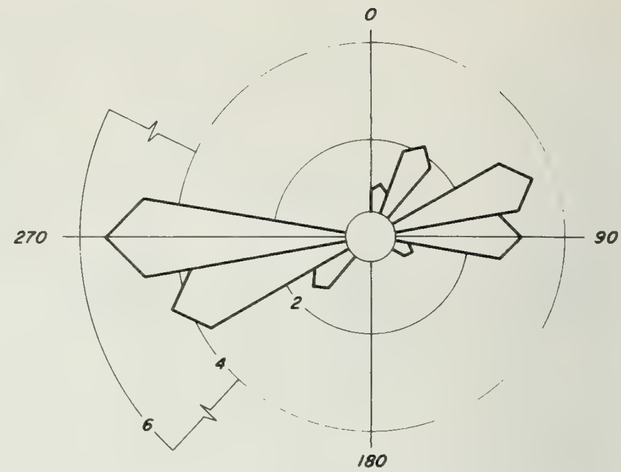


STATION 71 — CURRENT, KNOTS
DEPTH, FT 33 — MAX. 1.2
DATE JULY 14-15, 1953 — MEAN 0.69
REFERENCE FIG. 4-4 — MIN. 0.3
PERIOD OF OBSERVATION 0300 JULY 14-0400 JULY 15

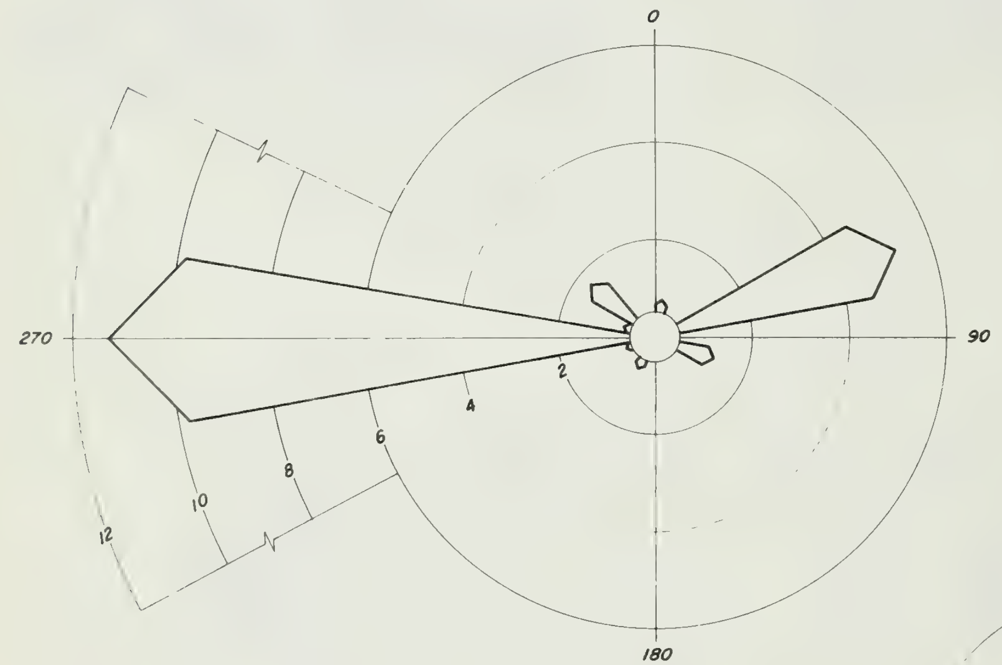
ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



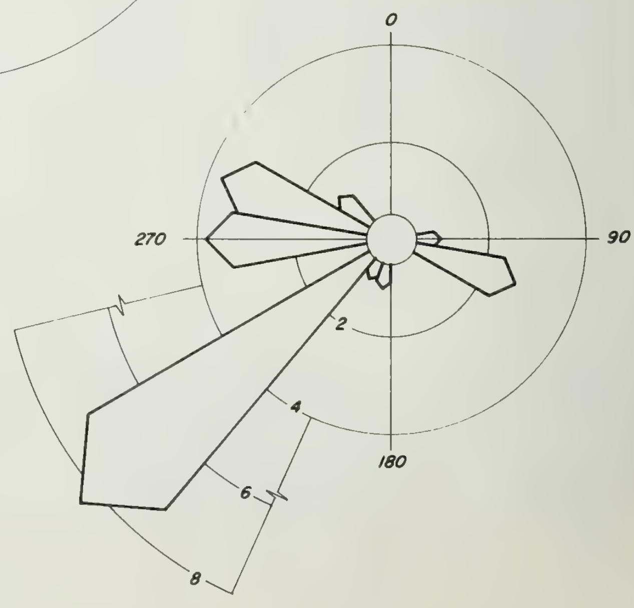
STATION	72	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.2
DATE	AUG. 5-6, 1953	MEAN	0.87
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	2200 AUG. 5 - 2300 AUG. 6		



STATION	72	CURRENT, KNOTS	
DEPTH, FT	26	MAX.	2.0
DATE	AUG. 5-6, 1953	MEAN	0.91
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	2200 AUG. 5 - 2300 AUG. 6		

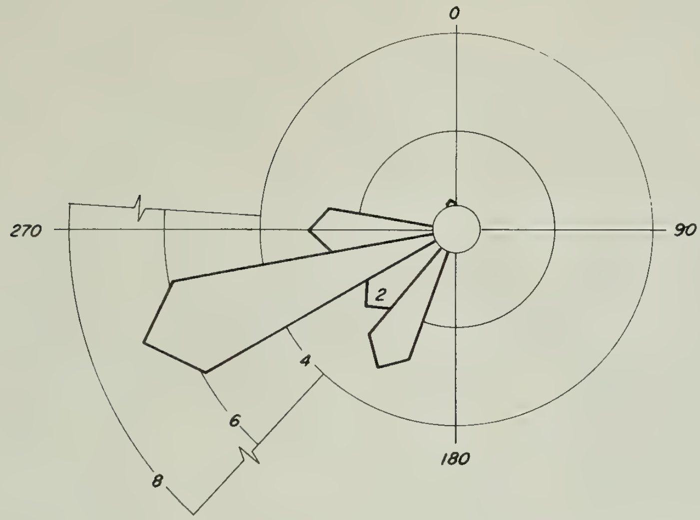


STATION	72	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.4
DATE	AUG. 9-10, 1953	MEAN	0.92
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	0100 AUG. 9 - 0200 AUG. 10		

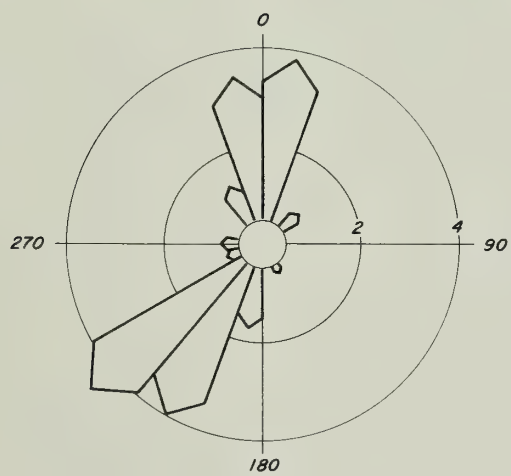


STATION	72	CURRENT, KNOTS	
DEPTH, FT	26	MAX.	2.0
DATE	AUG. 9-10, 1953	MEAN	0.95
REFERENCE FIG.	4-4	MIN.	0.3
PERIOD OF OBSERVATION	0100 AUG. 9 - 0200 AUG. 10		

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)

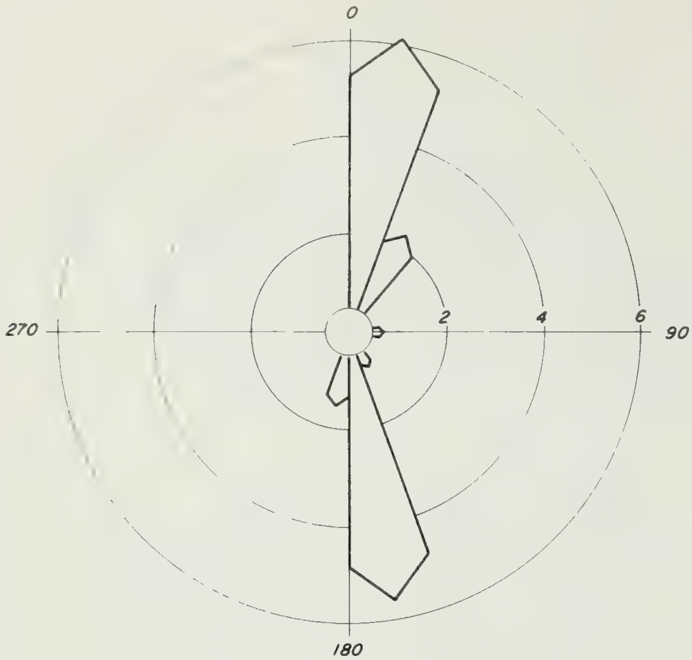


STATION	73	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	1.7
DATE	AUG. 2-3, 1953	MEAN	0.71
REFERENCE FIG.	4-4	MIN.	0.3
PERIOD OF OBSERVATION	1700 AUG. 2-1800 AUG. 3		

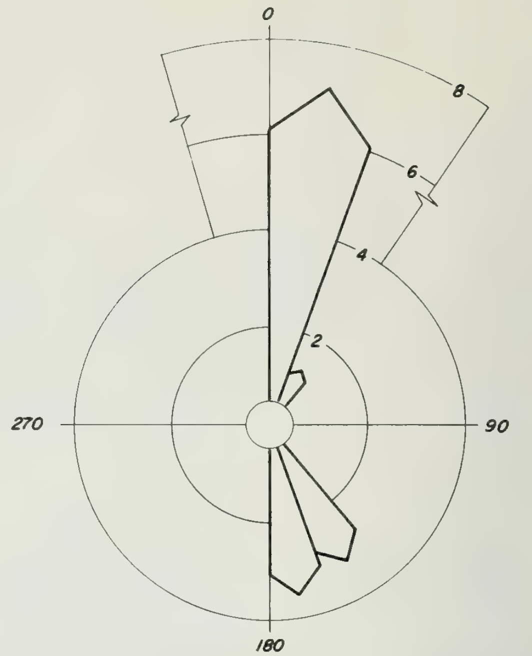


STATION	73	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	1.6
DATE	AUG. 2-3, 1953	MEAN	0.90
REFERENCE FIG.	4-4	MIN.	0.3
PERIOD OF OBSERVATION	1700 AUG. 2-1800 AUG. 3		

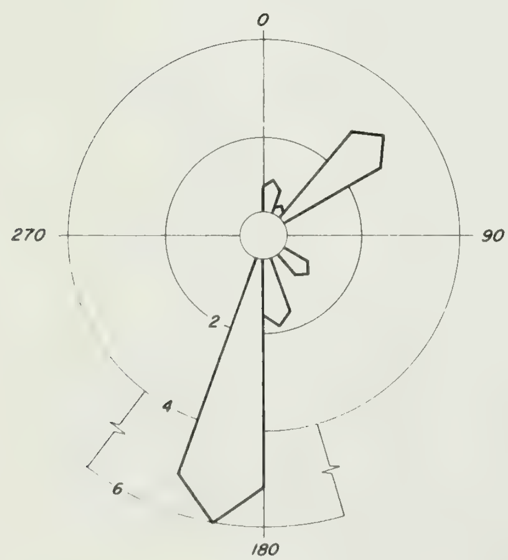
ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



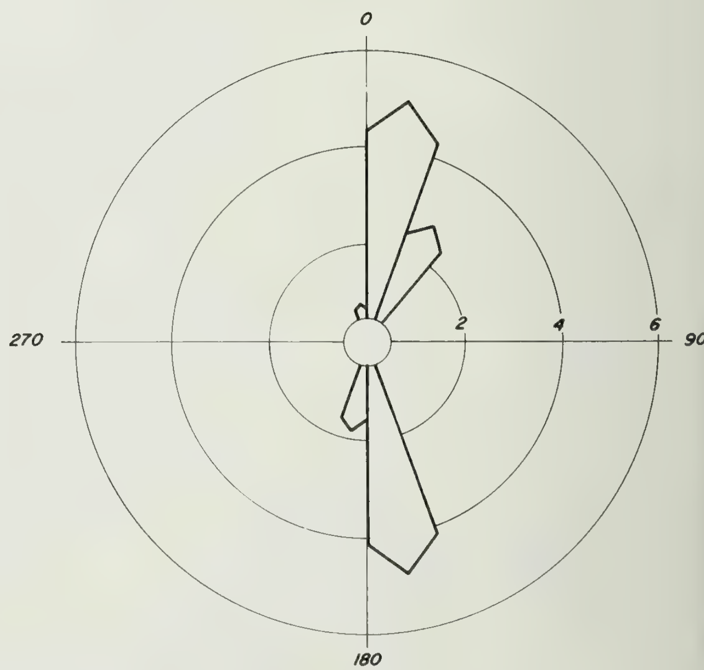
STATION	74	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	1.6
DATE	AUG. 12-13, 1953	MEAN	0.70
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	0200 AUG. 12-0300 AUG. 13		



STATION	74	CURRENT, KNOTS	
DEPTH, FT	19	MAX.	1.3
DATE	AUG. 12-13, 1953	MEAN	0.68
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	0200 AUG. 12-0300 AUG. 13		



STATION	74	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	1.4
DATE	AUG. 16-17, 1953	MEAN	0.62
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	1600 AUG. 16-1700 AUG. 17		



STATION	74	CURRENT, KNOTS	
DEPTH, FT	19	MAX.	1.4
DATE	AUG. 16-17, 1953	MEAN	0.66
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	1600 AUG. 16-1700 AUG. 17		

Gulf of the Farallones
Currents
Fall Season

Table 3. Fall Current Data Station A, Gulf of the Farallones

Dates collected: October 7 and 8, 1970

Meter type: Tsurumi TSK E-2 Current Meter

Station: A
Reference figure: 4-27
Water depth, feet: 45

Date: Time, PDST:	10-7-70 0845		10-7-70 1120		10-7-70 1230		10-7-70 1331	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	1.30	255	0.77	125	0.46	260	0.46	315
6	0.66	265	0.67	115	0.45	075	0.51	325
16	0.80	195	0.41	085	0.47	295	0.56	015
26	0.63	135	0.52	075	0.51	045	0.67	015
33	0.40	335	0.61	055	0.47	315	0.30	015
43			0.50	285	0.63	060		

Date: Time, PDST:	10-7-70 1526		10-7-70 1638		10-7-70 1730		10-7-70 1828	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.66	035	0.55	065	0.70	090	1.30	095
6	0.75	035	0.64	055	0.50	085	1.30	095
16	0.79	055	0.36	055	0.64	100	1.06	105
26	0.80	045	0.42	285	0.42	070	0.87	100
33	0.41	035	0.32	255	0.35	105	0.66	095
39			0.34	135				
43	0.40	315			0.22	075	0.64	125

Date: Time, PDST:	10-7-70 1926		10-7-70 2132		10-7-70 2230		10-7-70 2330	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	1.76	130	2.14	215	1.95	225	1.59	215
6	1.77	125	1.63	200	1.57	200	1.09	210
16	1.73	125	1.40	200	1.11	180	0.94	195
26	1.22	105	1.10	190	0.95	185	0.73	185
33	1.34	095	0.26	170	0.67	105	0.48	145
43	0.82	095	0.34	170				

Date: Time, PDST:	10-8-70 0030		10-8-70 0125		10-8-70 0325		10-8-70 0446	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.77	245	0.46	295	0.60	055	1.75	025
6	0.63	195	0.34	285	1.29	025	1.47	025
16	0.51	175	0.35	295	2.16	025	1.25	040
26	0.46	150	0.66	345	1.06	025	1.04	025
33	0.37	105	0.53	315	1.97	025	0.76	025
39							0.73	025

[a]Direction of movement in degrees measured clockwise from true north.

Continued on next page

Tabel 3. Continued

Dates collected: October 7 and 8, 1970

Meter type: Tsurumi TSK E-2 Current Meter

Station A
Reference figure: 4-27
Water depth, feet: 45

Date: Time, PDST:	10-8-70 0547		10-8-70 0639		10-8-70 0739		10-8-70 0941	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	1.43	015	1.00	045	0.87	040	0.46	125
6	0.95	015	0.80	030	0.67	045	0.92	110
16	0.95	015	0.56	025	0.52	035	1.06	135
26	0.75	015	0.50	065	0.32	025	0.50	105
33	0.70	015	0.40	335	0.30	285	0.36	095
39							0.47	175

Date: Time, PDST:	10-8-70 1036		10-8-70 1127		10-8-70 1229		10-8-70 1327	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	1.27	200	1.24	200	0.56	185	0.65	040
6	2.04	175	0.82	190	0.61	145	0.31	270
16	0.85	145	0.82	155	0.61	145	0.31	160
26	0.45	125	0.63	115	0.56	105	0.37	075
33	0.32	135	0.32	095	0.46	065	0.41	025

Date: Time, PDST:	10-8-70 1432		10-8-70 1528	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.58	015	0.73	015
6	0.43	030	0.63	035
16	0.43	025	0.70	030
26	0.60	030	0.70	015
33	0.56	025	0.52	015

[a]Direction of movement in degrees measured clockwise from true north.

Table 4. Fall Current Data Station B, Gulf of the Farallones

Dates collected: October 7, 10 and 11, 1970

Meter type: Tsurumi TSK E-2 Current Meter

Station: B
Reference figure: 4-27
Water depth, feet: 90

Date: Time, PDST:	10-7-70 0955		10-10-70 0920		10-10-70 1035		10-10-70 1129	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.77	045	0.64	015	0.47	015	0.33	185
16	0.55	315	0.41	000	0.33	235	0.32	175
33	0.66	075	0.47	025	0.35	005	0.34	205
49	0.41	065	0.32	345	0.26	275	0.60	195
66	0.51	105	0.32	195	0.38	325	0.65	265
82	0.55	125	<0.20	325	0.26	245	0.24	305

Date: Time, PDST:	10-10-70 1229		10-10-70 1332		10-10-70 1430		10-10-70 1532	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.46	135	0.35	135	0.48	105	0.58	115
16	0.25	195	0.40	195	0.37	155	0.63	105
33	0.26	345	0.47	285	0.37	165	0.33	210
49	0.66	285	0.47	315	0.21	225	0.37	005
66	0.33	355	0.49	315	0.33	195	0.48	285
82	0.20	345	<0.20	255	<0.20	335	<0.20	160

Date: Time, PDST:	10-10-70 1632		10-10-70 1730		10-10-70 1831		10-10-70 1929	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.53	105	0.50	065	0.54	070	0.67	150
16	0.54	135	0.41	120	0.26	275	0.46	315
33	0.34	000	0.46	050	0.37	135	0.35	015
49	0.50	015	0.82	030	0.66	015	0.46	015
66	0.48	045	0.66	040	0.40	015	0.41	085
82	0.34	015	0.35	315	<0.20	145	<0.20	075

Date: Time, PDST;	10-10-70 2031		10-10-70 2128		10-10-70 2230		10-10-70 2330	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.53	145	0.43	105	0.33	195	0.81	245
16	0.30	165	0.40	055	0.43	115	0.60	195
33	0.35	030	0.26	245	0.40	125	0.48	170
49	0.37	060	0.43	135	0.50	175	0.52	170
66	0.26	015	0.34	105	0.43	195	0.41	155
82	0.20	005	<0.20	085	0.21	115	0.25	160

[a]Direction of movement in degrees measured clockwise from true north.

Continued on next page

Table 4. Continued

Dates collected: October 7, 10 and 11, 1970

Meter type: Tsurumi TSK E-2 Current Meter

Station: B
Reference figure: 4-27
Water depth, feet: 90

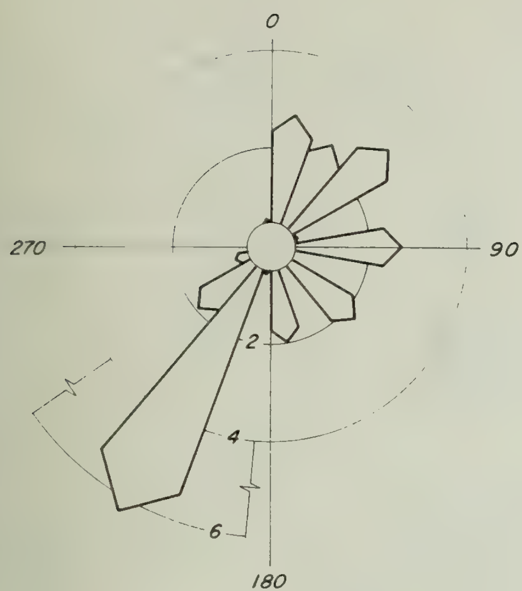
Date: Time, PDST:	10-11-70 0030		10-11-70 0130		10-11-70 0229		10-11-70 0330	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.81	295	0.52	285	1.03	325	0.82	295
16	1.04	270	0.66	315	0.53	320	0.52	285
33	0.41	185	0.47	255	0.43	015	0.46	205
49	0.40	165	0.47	180	0.32	245	0.43	045
66	0.43	110	0.41	095	0.47	055	0.41	075
82	0.24	135	0.21	045	0.23	285	0.20	035

Date: Time, PDST:	10-11-70 0430		10-11-70 0530		10-11-70 0630		10-11-70 0751	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.71	295	0.92	015	0.96	025	0.94	305
16	0.66	285	0.92	345	0.92	015	1.05	300
33	0.53	285	0.57	015	0.40	045	0.55	015
49	0.32	000	0.50	030	0.41	070	0.50	325
66	0.38	010	0.49	030	0.50	075	0.40	290
82	<0.20	080			0.26	125		

Date: Time, PDST:	10-11-70 0852		10-11-70 1017	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.86	315	0.28	230
16	0.73	005	0.26	235
33	0.50	015	0.23	235
49	0.33	315	0.24	240
66	0.26	285	0.26	225
82			0.28	205

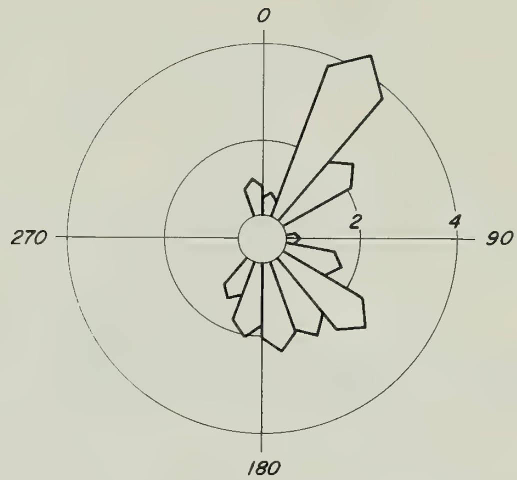
[a]Direction of movement in degrees measured clockwise from true north.

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



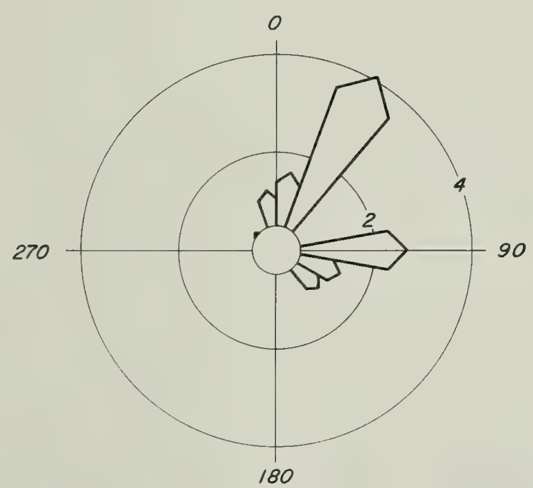
STATION	A	CURRENT, KNOTS	
DEPTH, FT	SURFACE	MAX.	2.14
DATE	OCT. 7-8, 1970	MEAN	1.05
REFERENCE FIG.	4-27	MIN.	046

PERIOD OF OBSERVATION 1526 OCT. 7 - 1531 OCT. 8



STATION	A	CURRENT, KNOTS	
DEPTH, FT	16	MAX.	2.16
DATE	OCT. 7-8, 1970	MEAN	0.91
REFERENCE FIG.	4-27	MIN.	0.31

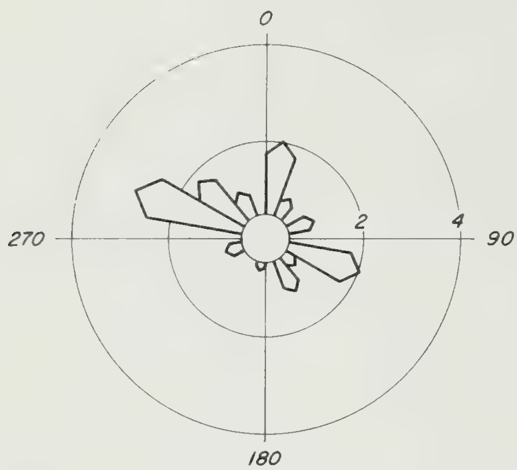
PERIOD OF OBSERVATION 1526 OCT. 7 - 1531 OCT. 8



STATION	A	CURRENT, KNOTS	
DEPTH, FT	33	MAX.	1.97
DATE	OCT. 7-8, 1970	MEAN	0.60
REFERENCE FIG.	4-27	MIN.	0.26

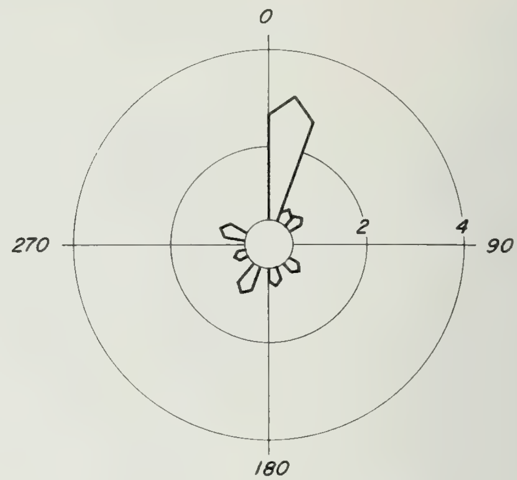
PERIOD OF OBSERVATION 1526 OCT. 7 - 1531 OCT. 8

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



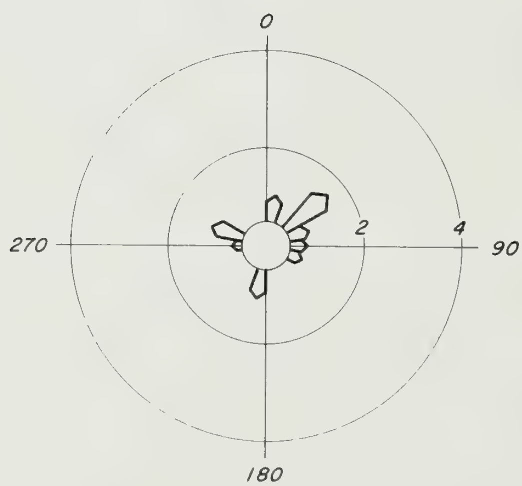
STATION B
DEPTH, FT SURFACE
DATE OCT. 10-11, 1970
REFERENCE FIG. 4-27
PERIOD OF OBSERVATION 0920 OCT. 10 - 1026 OCT. 11

CURRENT, KNOTS
MAX. 1.03
MEAN 0.62
MIN. 0.28



STATION B
DEPTH, FT 33
DATE OCT. 10-11, 1970
REFERENCE FIG. 4-27
PERIOD OF OBSERVATION 0920 OCT. 10 - 1026 OCT. 11

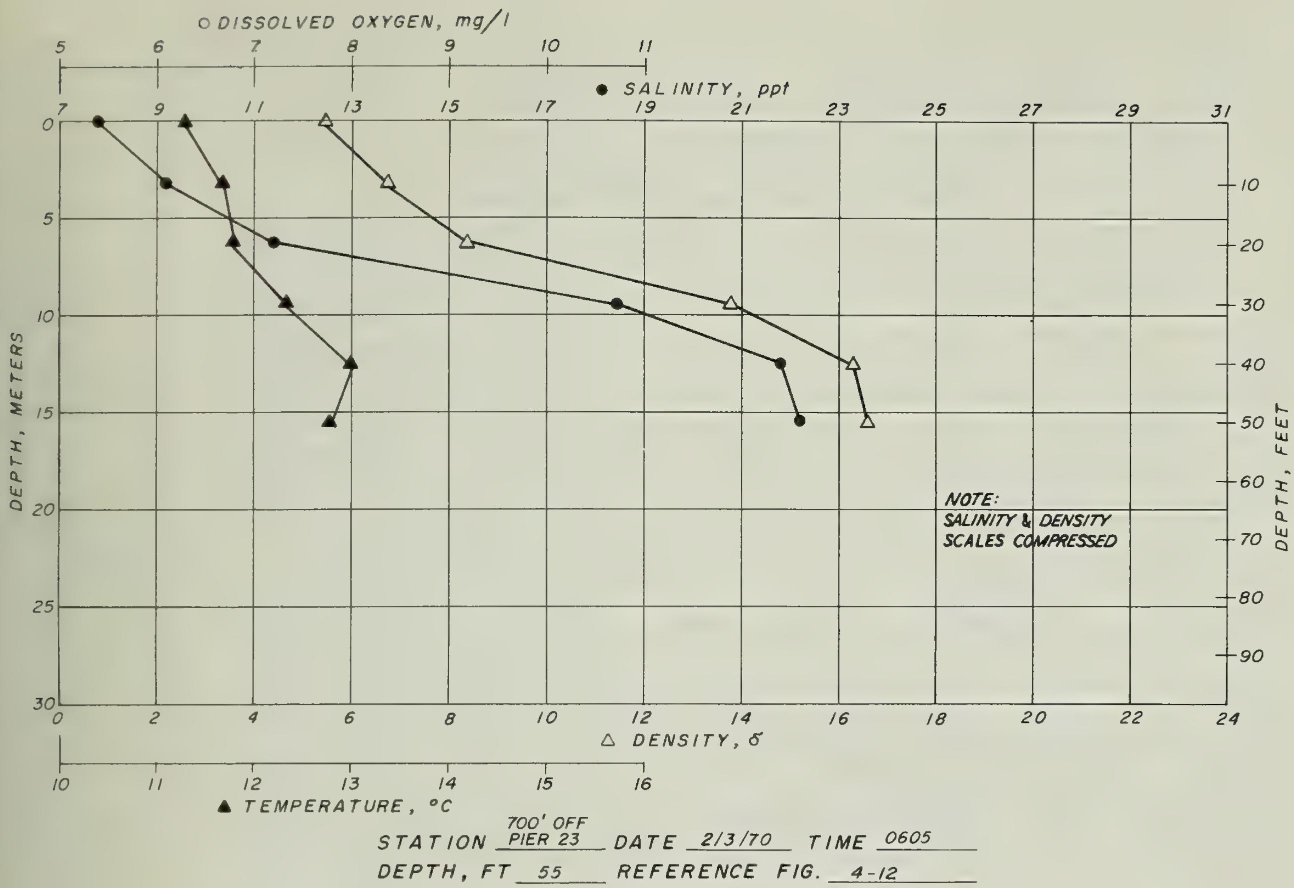
CURRENT, KNOTS
MAX. 0.57
MEAN 0.41
MIN. 0.23

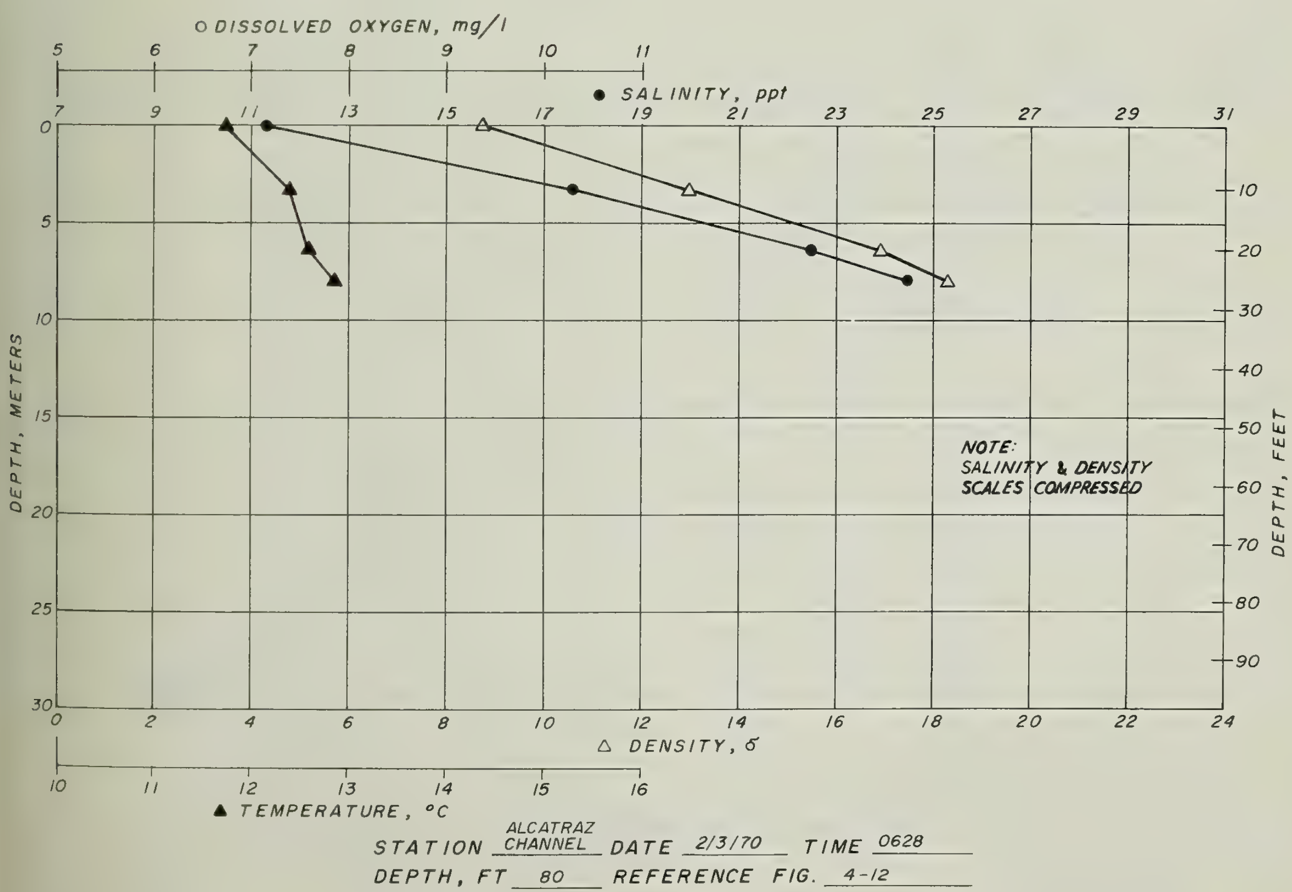


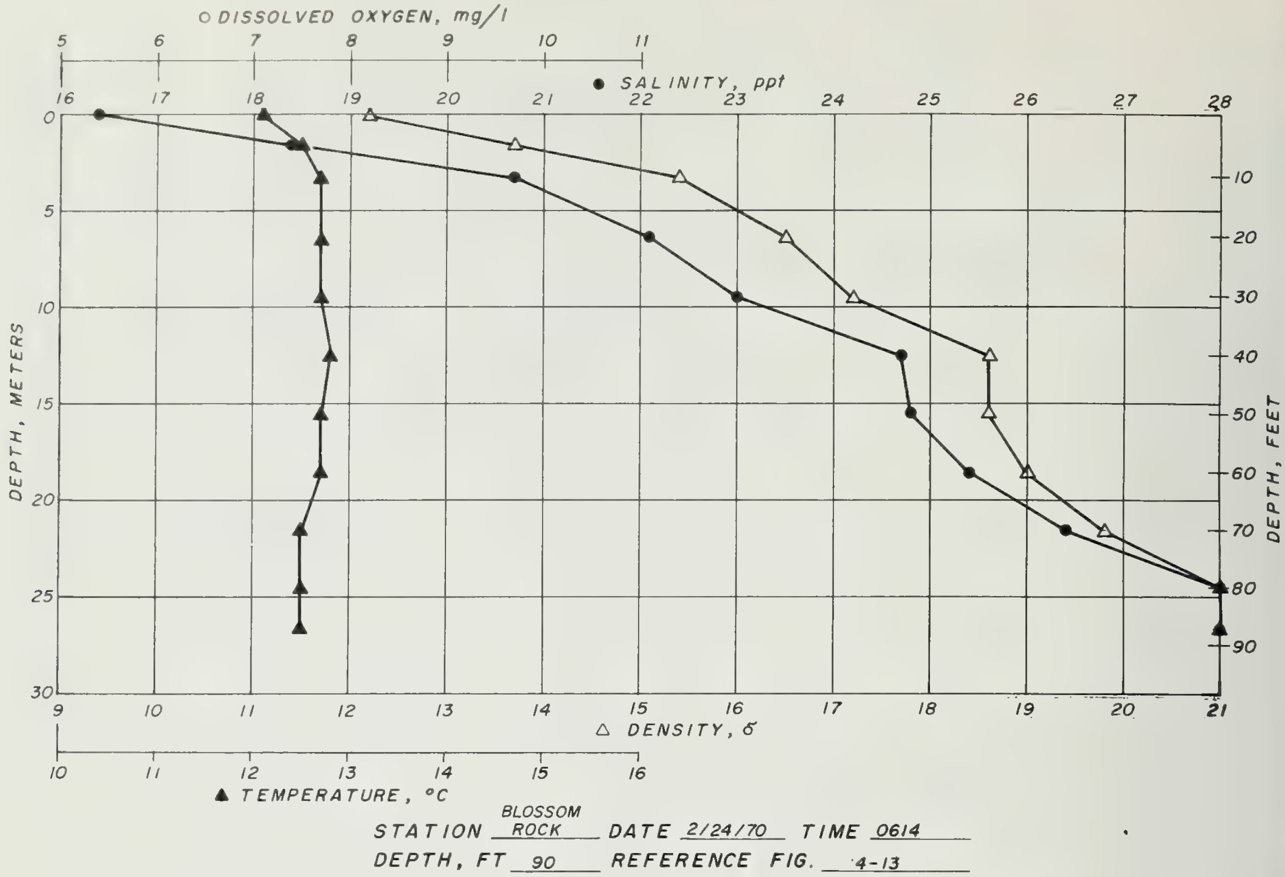
STATION B
DEPTH, FT 66
DATE OCT. 10-11, 1970
REFERENCE FIG. 4-27
PERIOD OF OBSERVATION 0920 OCT. 10 - 1026 OCT. 11

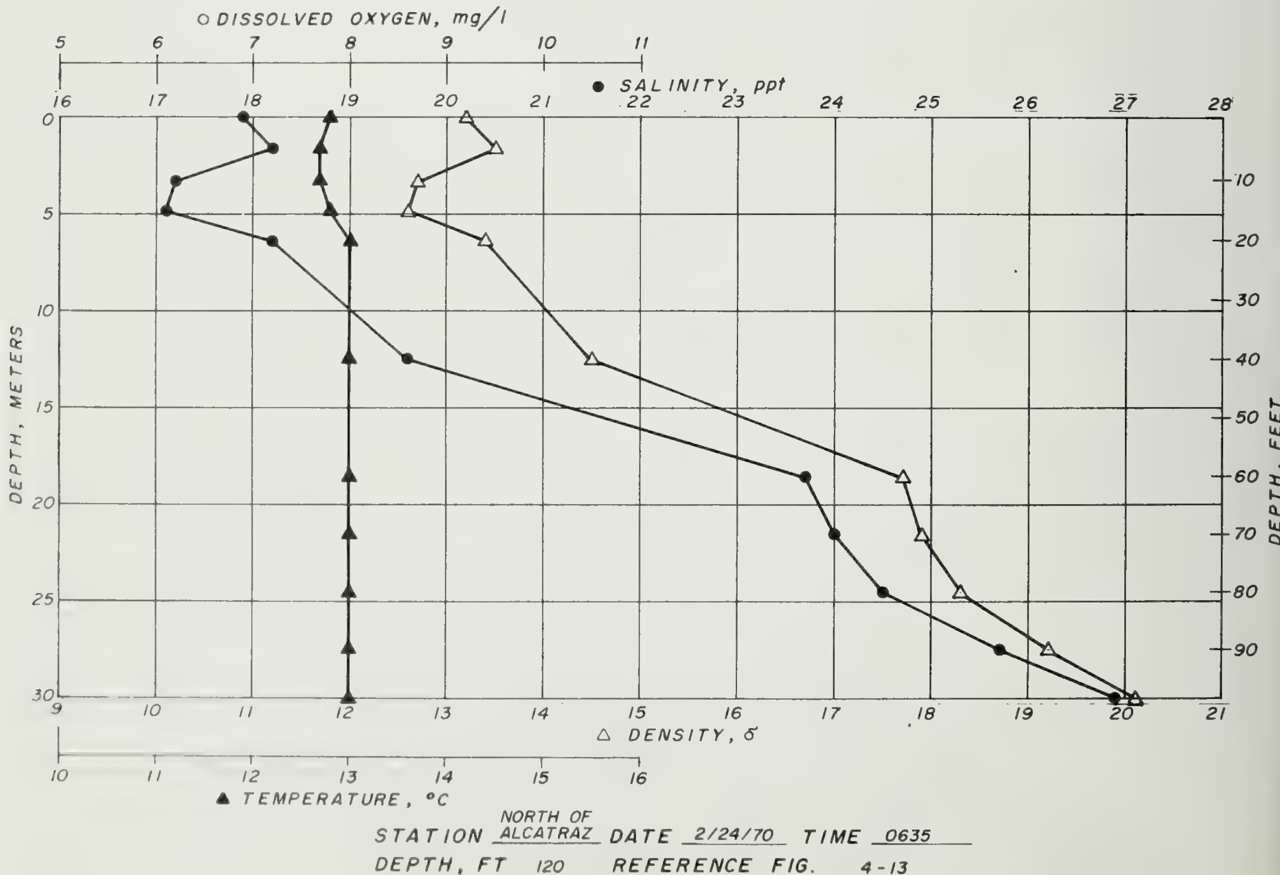
CURRENT, KNOTS
MAX. 0.66
MEAN 0.42
MIN. 0.26

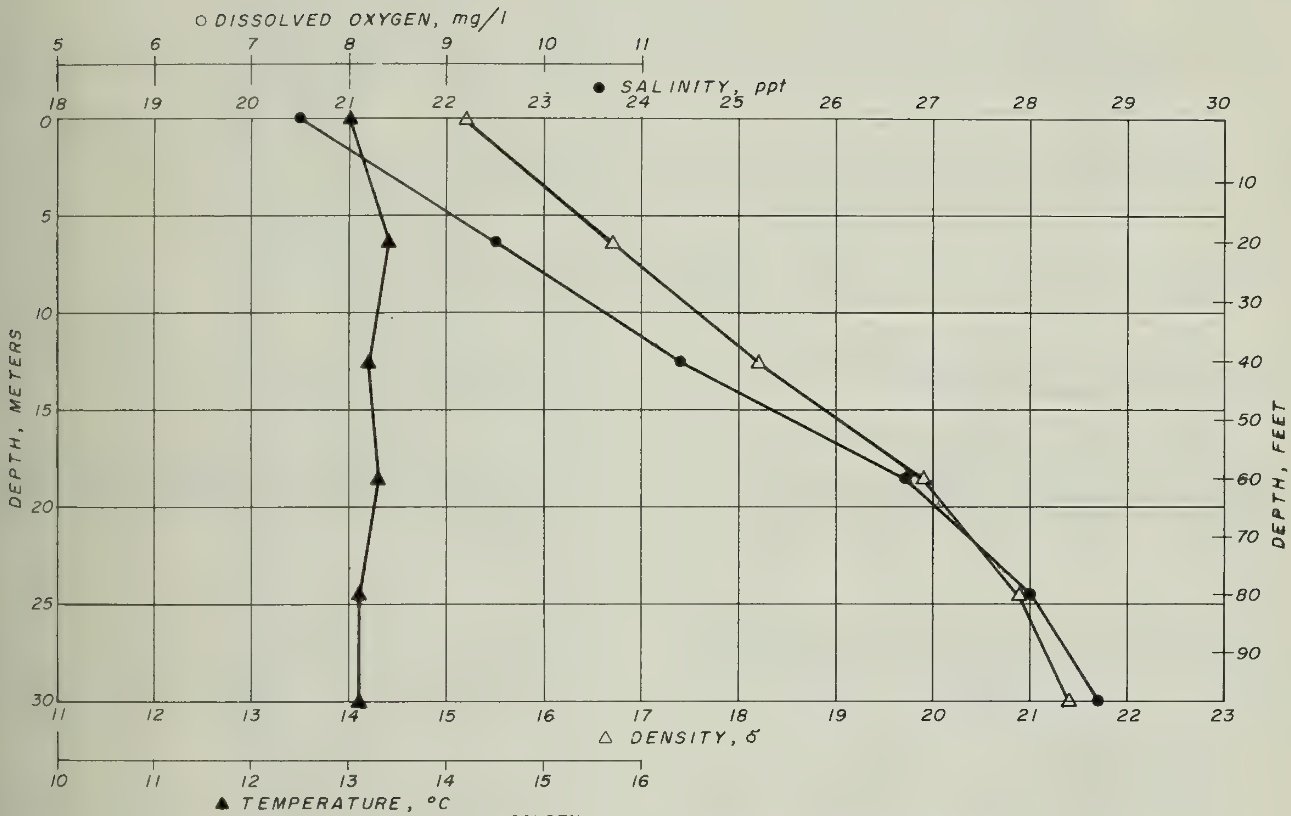
San Francisco Bay
Physical - Chemical Characteristics


O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
NOTE:
SALINITY & DENSITY
SCALES COMPRESSED
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION 700' OFF PIER 23 DATE 2/3/70 TIME 0605
DEPTH, FT 55 REFERENCE FIG. 4-12


O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
NOTE:
SALINITY & DENSITY
SCALES COMPRESSED
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION ALCATRAZ CHANNEL DATE 2/3/70 TIME 0628
DEPTH, FT 80 REFERENCE FIG. 4-12

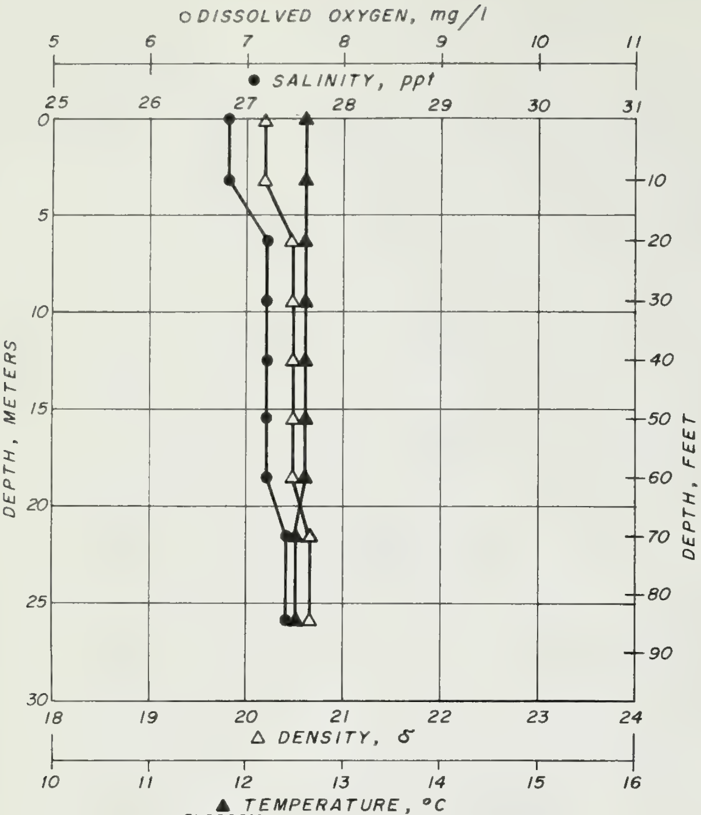

O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION BLOSSOM ROCK DATE 2/24/70 TIME 0614
DEPTH, FT 90 REFERENCE FIG. 4-13


O DISSOLVED OXYGEN, mg/l
● SALINITY, ppt
DEPTH, METERS
DEPTH, FEET
△ DENSITY, σ
▲ TEMPERATURE, °C
STATION NORTH OF ALCATRAZ DATE 2/24/70 TIME 0635
DEPTH, FT 120 REFERENCE FIG. 4-13

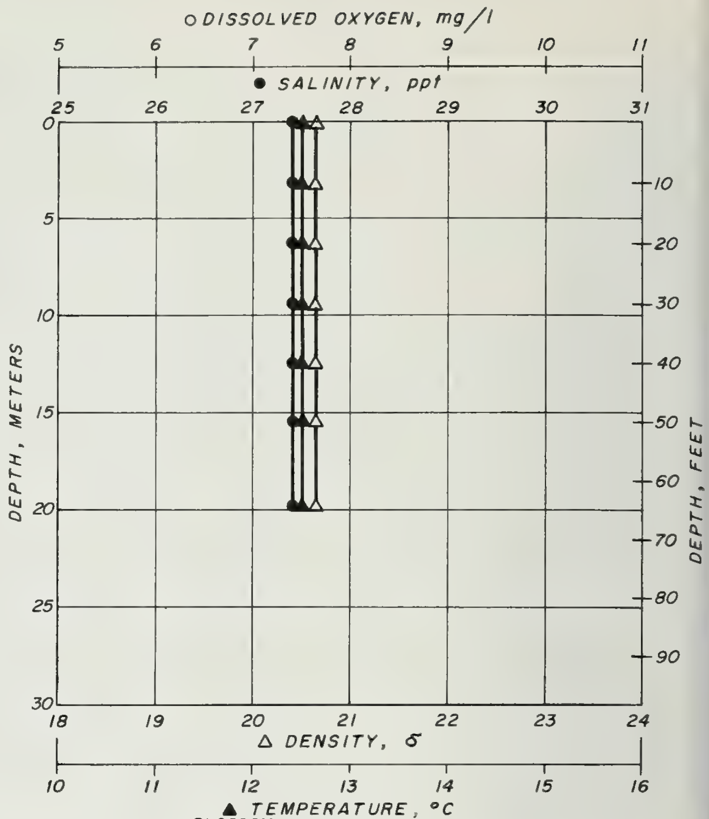


STATION GOLDEN GATE DATE 2/24/70 TIME 0656

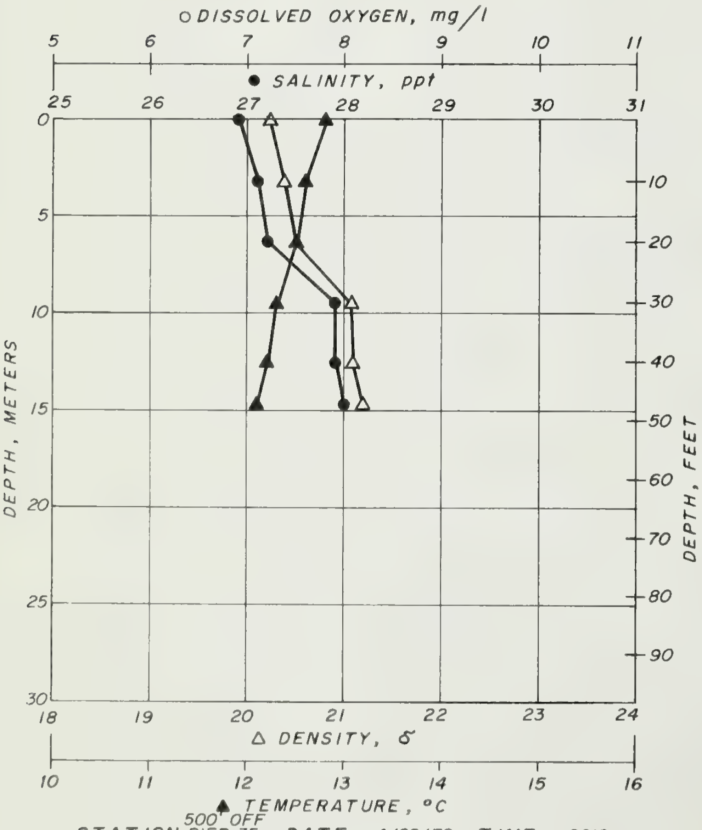
DEPTH, FT 150 REFERENCE FIG. 4-13



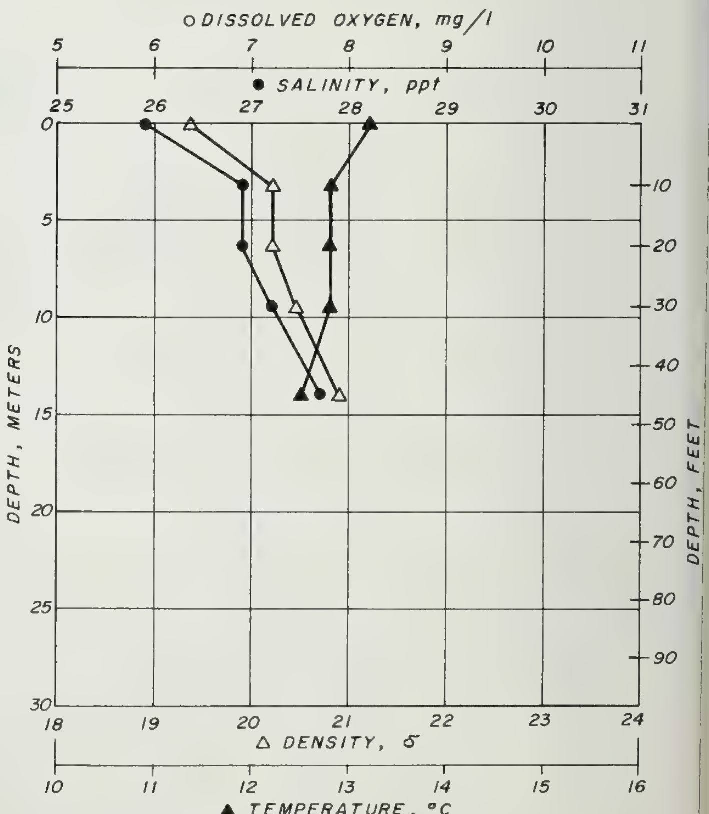
STATION BLOSSOM ROCK DATE 4/22/70 TIME 0505
DEPTH, FT 84 REFERENCE FIG. 4-45



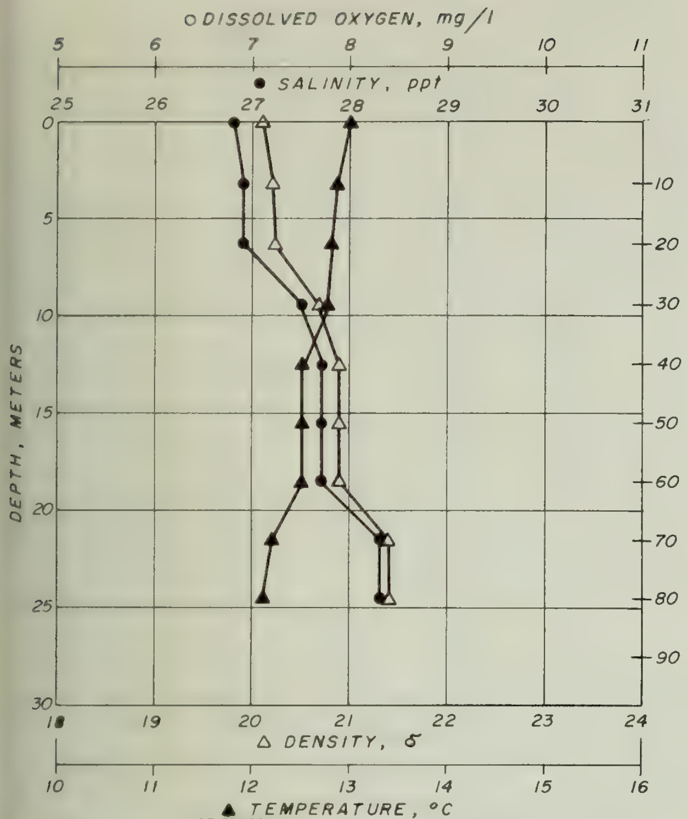
STATION BLOSSOM ROCK DATE 4/22/70 TIME 0547
DEPTH, FT 64 REFERENCE FIG. 4-45



STATION 500' OFF PIER 35 DATE 4/22/70 TIME 0618
DEPTH, FT 47 REFERENCE FIG. 4-45

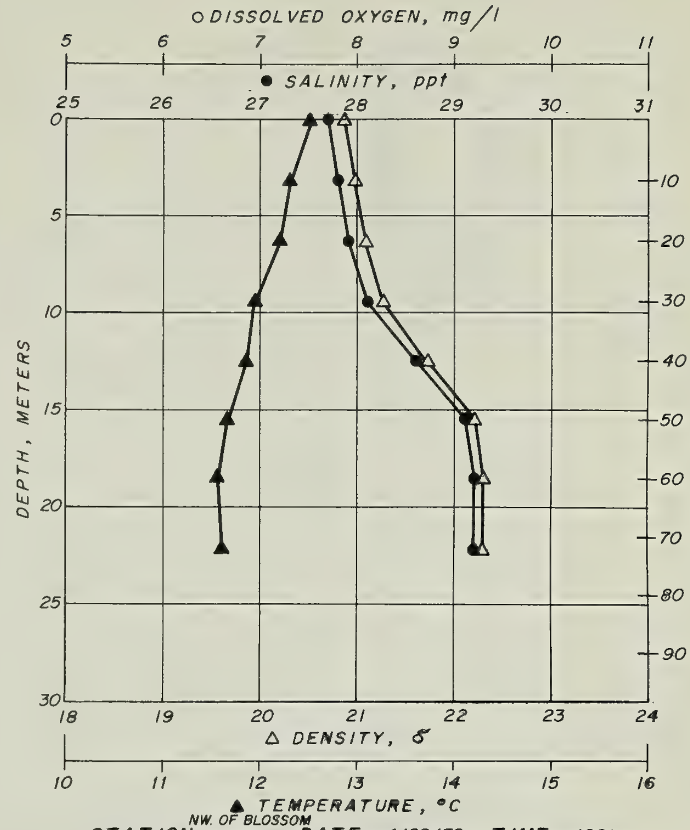


STATION 900' OFF PIER 37 DATE 4/22/70 TIME 0738
DEPTH, FT 45 REFERENCE FIG. 4-45



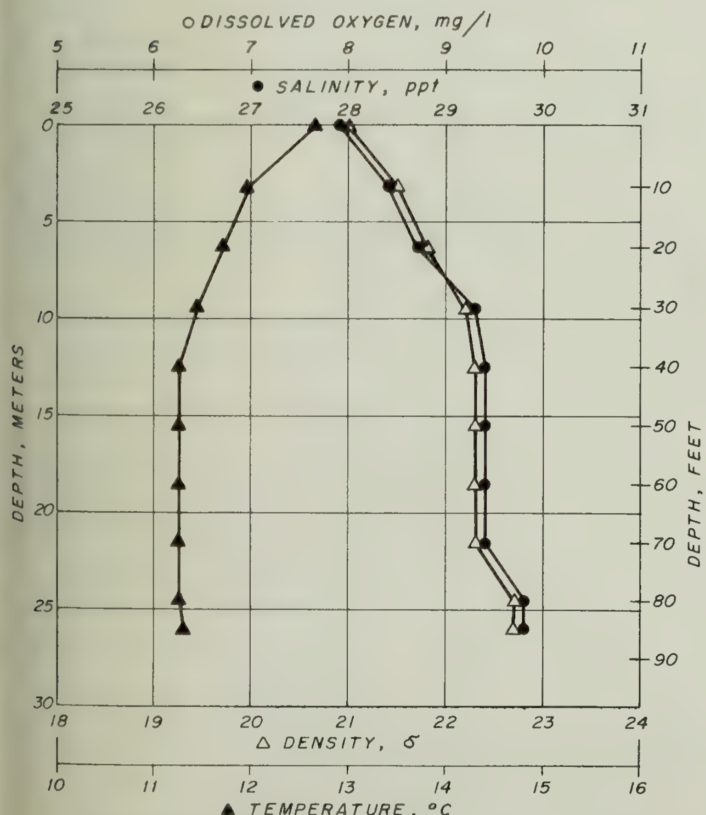
STATION W. OF BLOSSOM ROCK DATE 4/22/70 TIME 0756

DEPTH, FT 80 REFERENCE FIG. 4-45



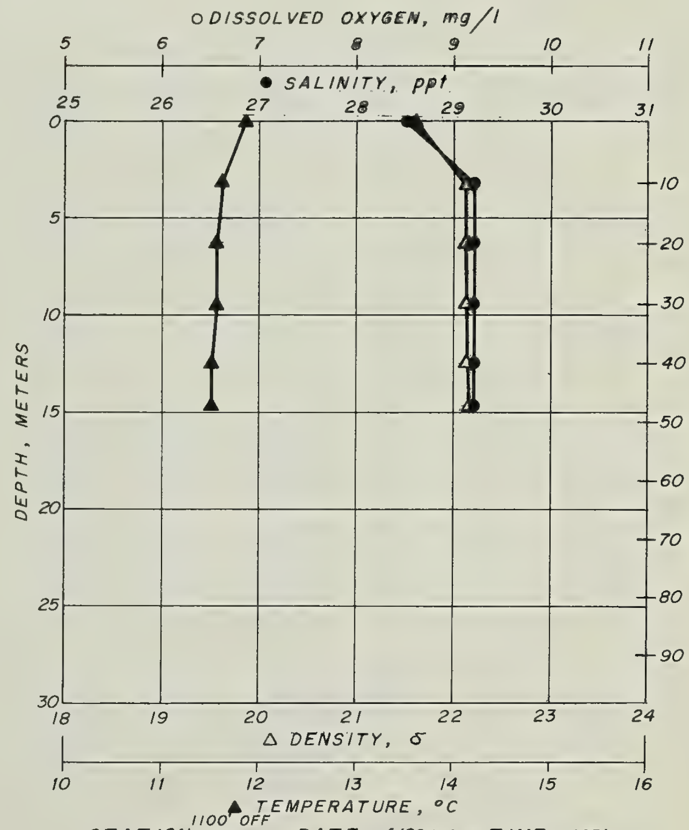
STATION NW. OF BLOSSOM ROCK DATE 4/22/70 TIME 1001

DEPTH, FT 72 REFERENCE FIG. 4-45



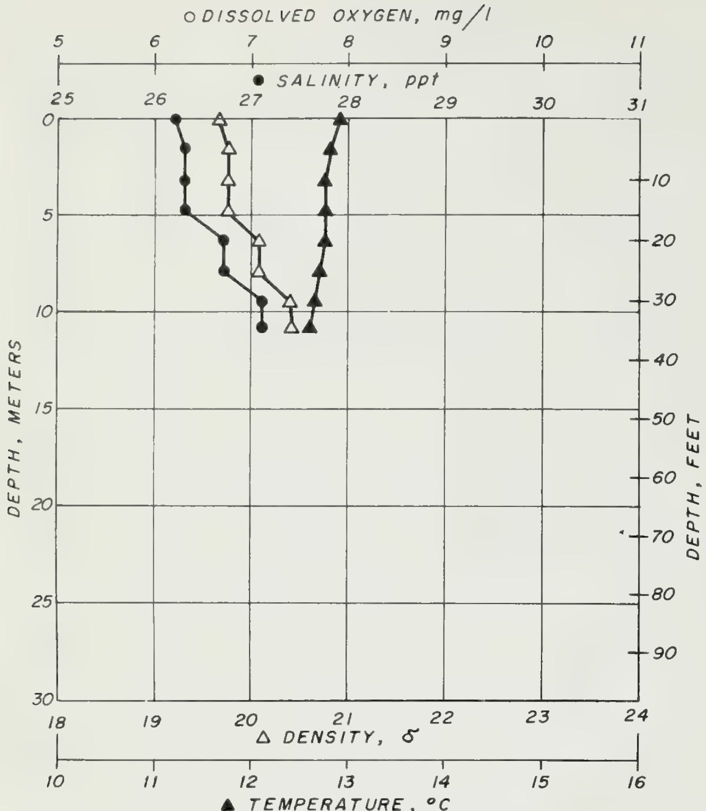
STATION W OF BLOSSOM ROCK DATE 4/22/70 TIME 1014

DEPTH, FT 85 REFERENCE FIG. 4-45

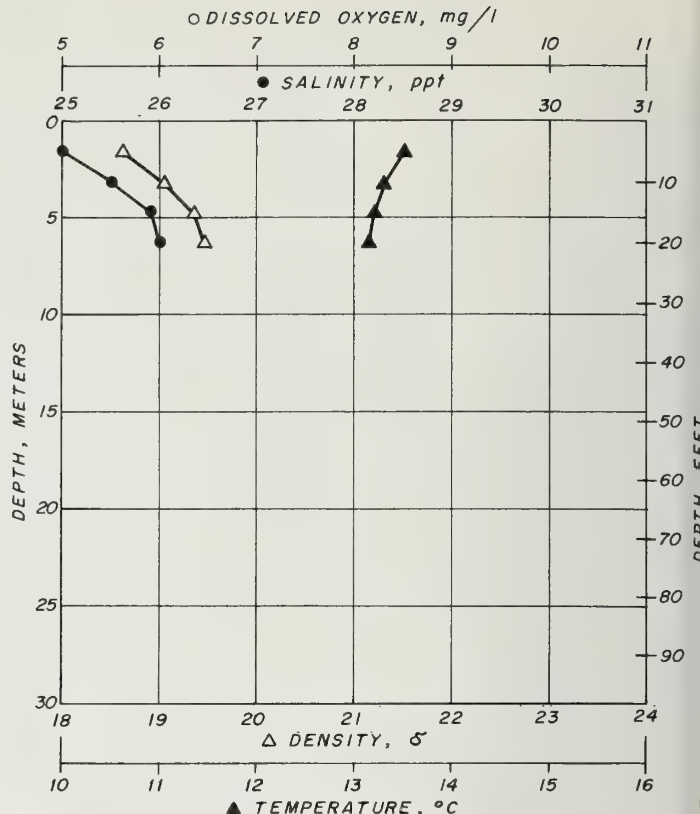


STATION 1100' OFF PIER 41 DATE 4/22/70 TIME 1031

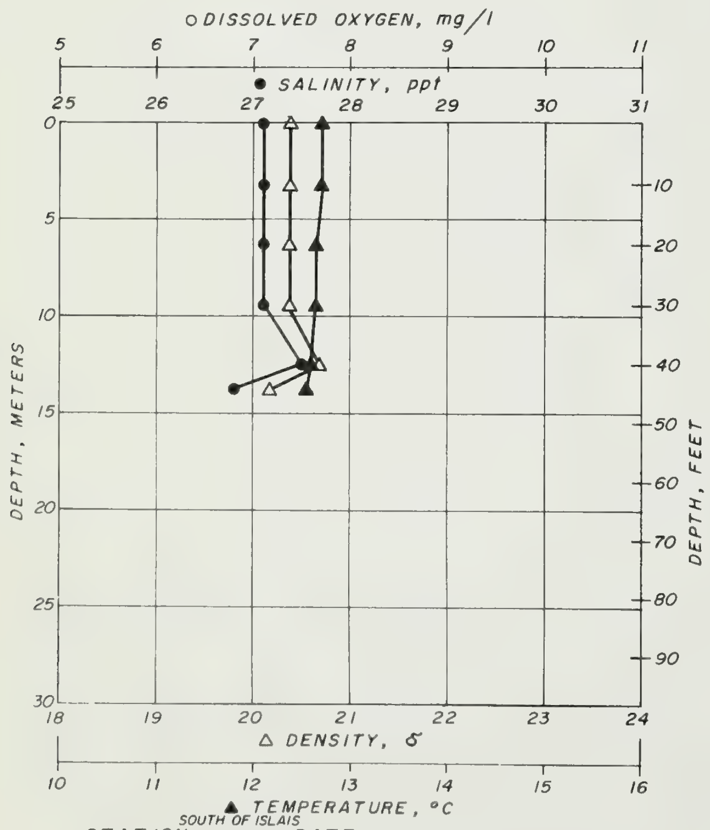
DEPTH, FT 47 REFERENCE FIG. 4-45



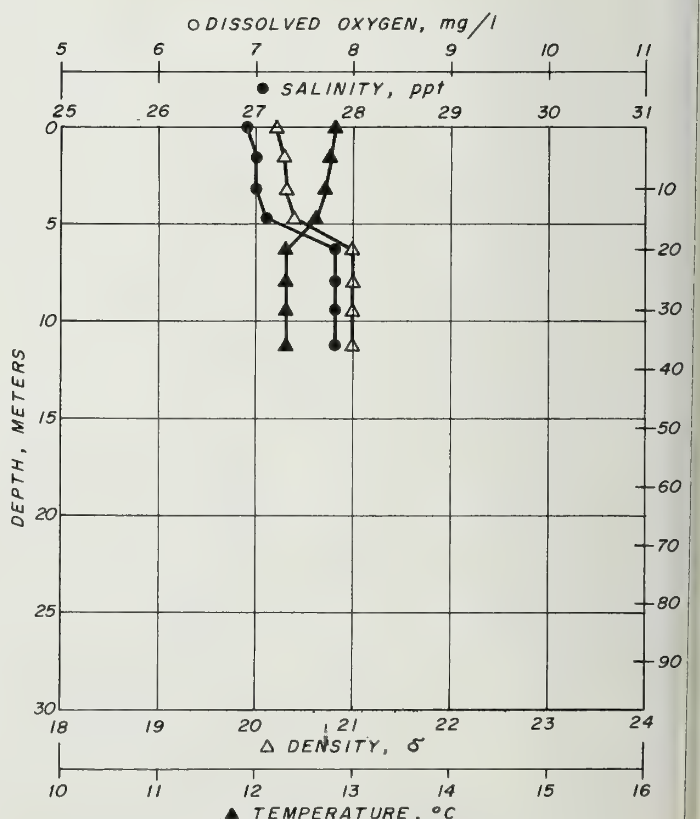
STATION 600' OFF ARMY ST. TERMINAL DATE 4/23/70 TIME 0755
DEPTH, FT 34 REFERENCE FIG. 4-47



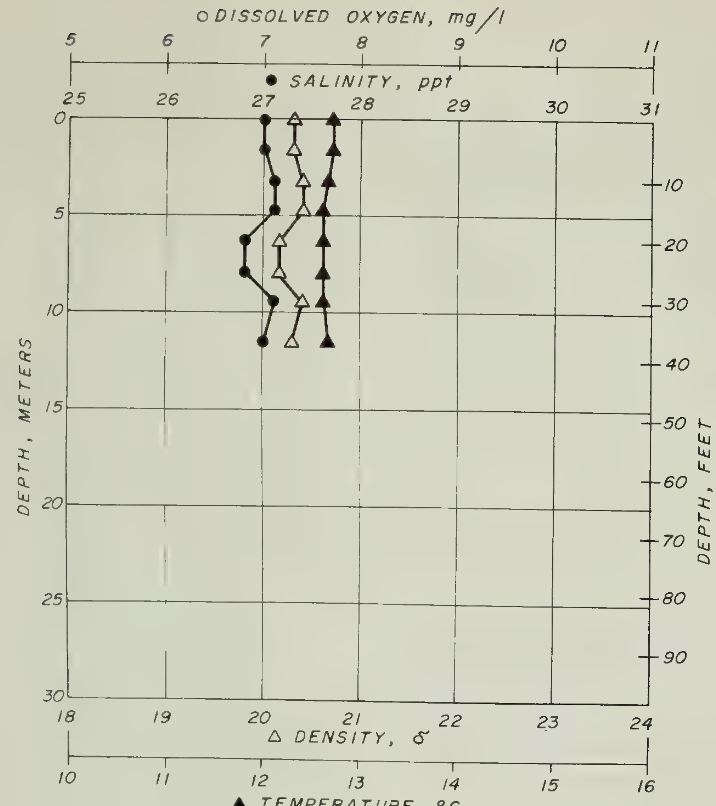
STATION SOUTH OF ISLAIS CREEK DATE 4/23/70 TIME 0942
DEPTH, FT 20 REFERENCE FIG. 4-47



STATION SOUTH OF ISLAIS CREEK DATE 4/23/70 TIME 1248
DEPTH, FT 44 REFERENCE FIG. 4-47

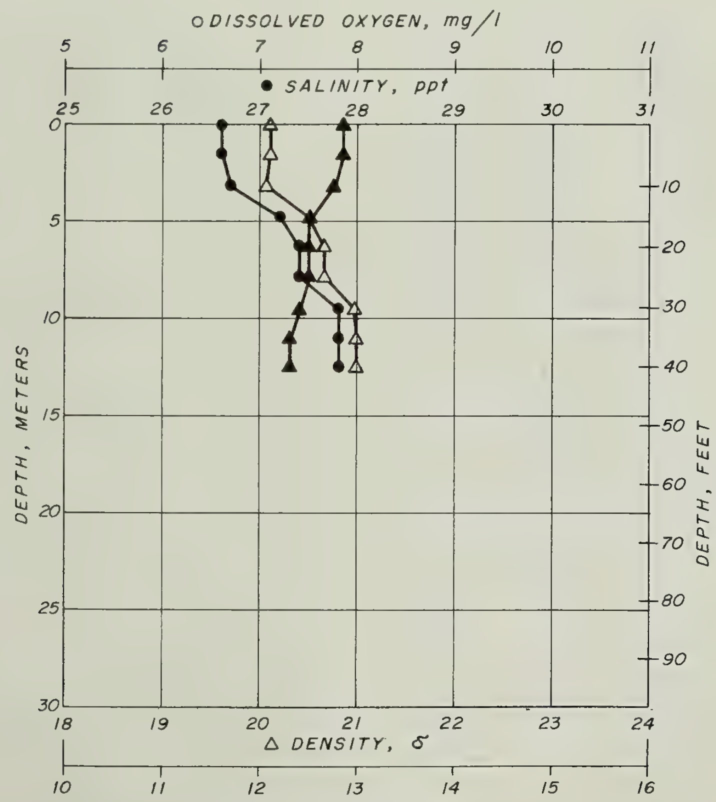


STATION 2300' OFF POTRERO POINT DATE 4/23/70 TIME 1506
DEPTH, FT 36 REFERENCE FIG. 4-47



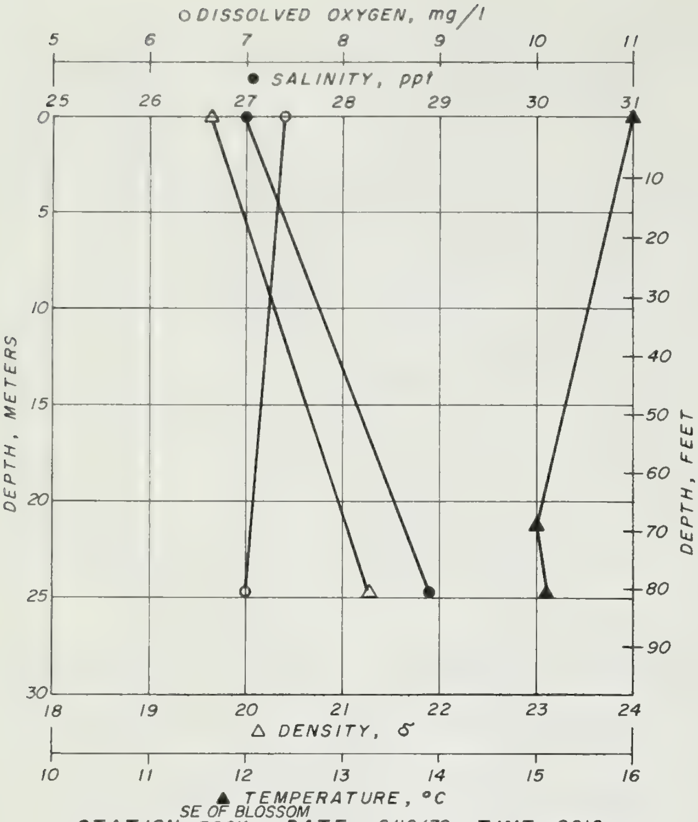
STATION 700' OFF ISLAIS CREEK DATE 4/23/70 TIME 1523

DEPTH, FT 37 REFERENCE FIG. 4-47

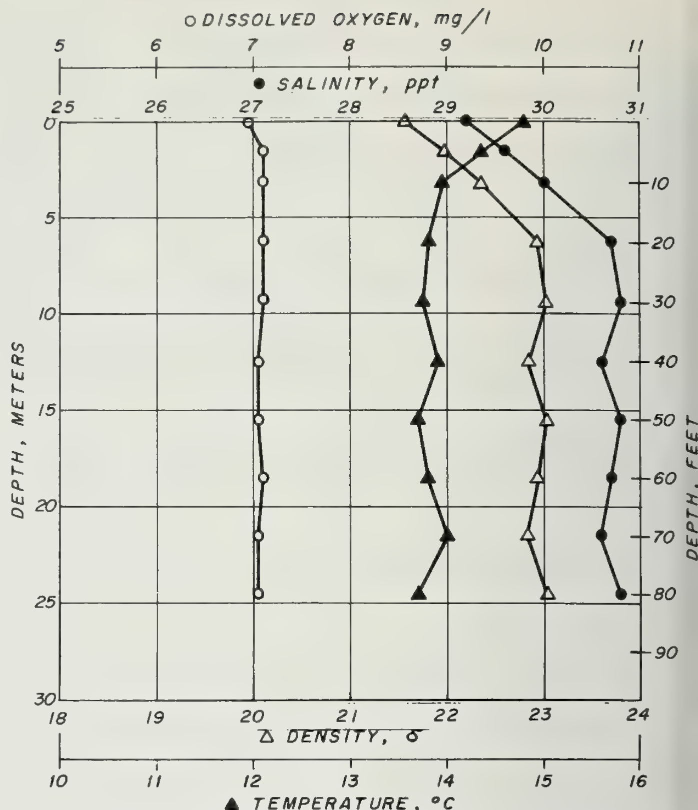


STATION 3500' OFF ARMY ST. TERMINAL DATE 4/23/70 TIME 1532

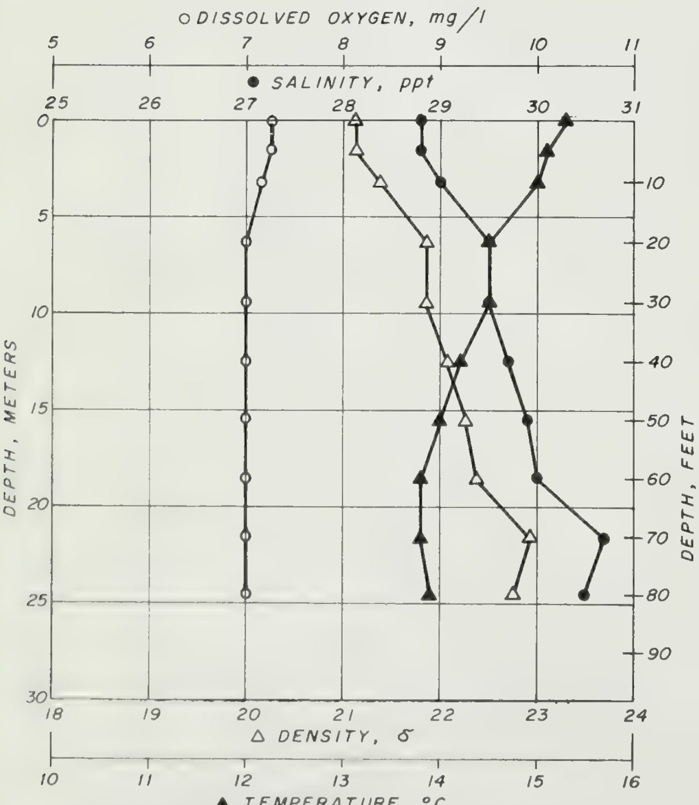
DEPTH, FT 40 REFERENCE FIG. 4-47



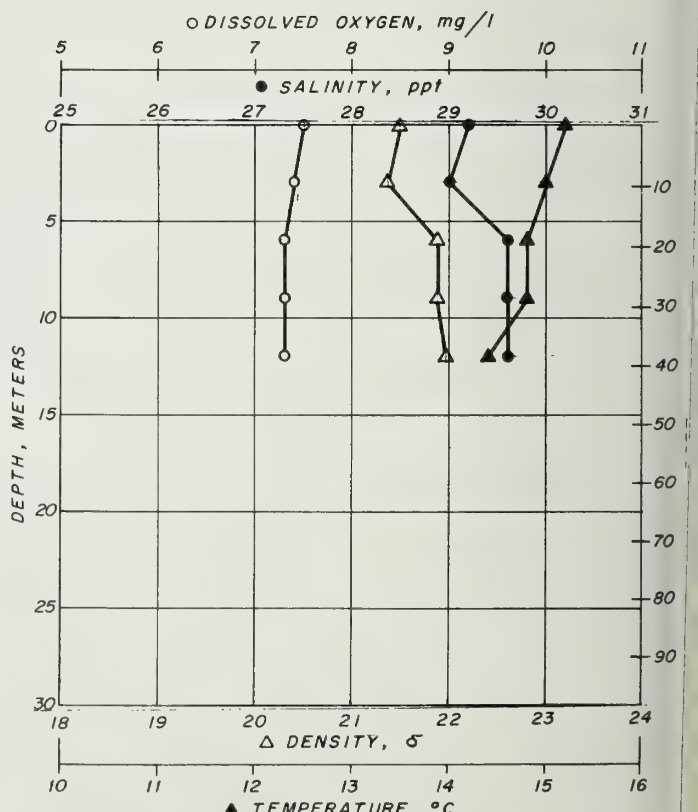
STATION SE OF BLOSSOM ROCK DATE 6/16/70 TIME 0818
DEPTH, FT 85 REFERENCE FIG. 4-39



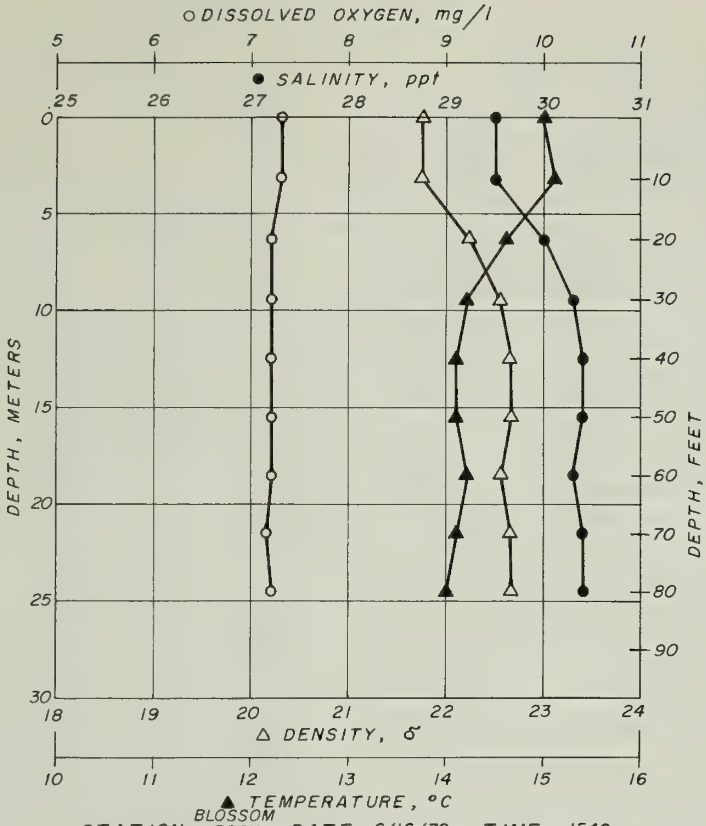
STATION BLOSSOM ROCK DATE 6/16/70 TIME 1126
DEPTH, FT 90 REFERENCE FIG. 4-39



STATION BLOSSOM ROCK DATE 6/16/70 TIME 1256
DEPTH, FT 90 REFERENCE FIG. 4-39

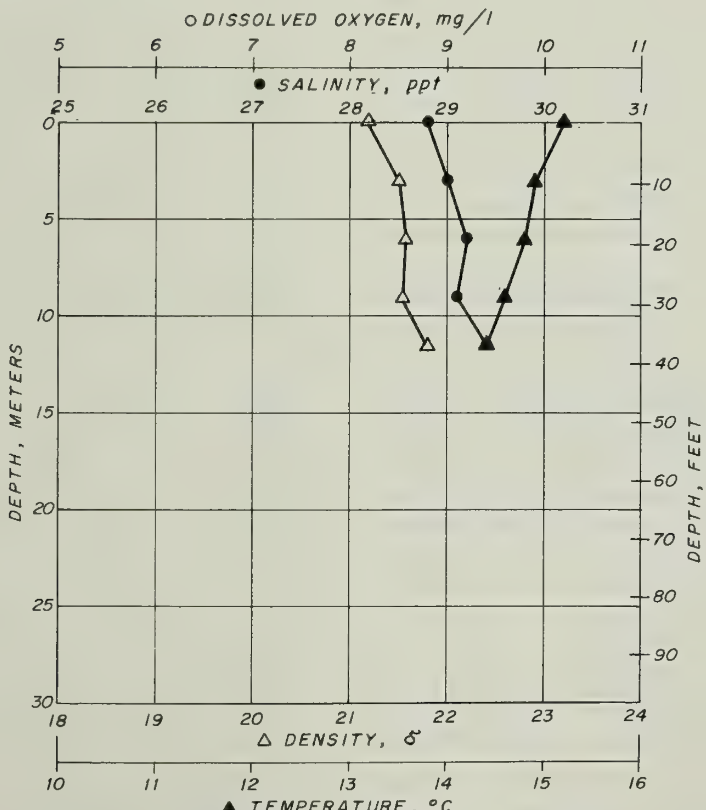


STATION EAST OF ALCATRAZ DATE 6/16/70 TIME 1420
DEPTH, FT 60 REFERENCE FIG. 4-39



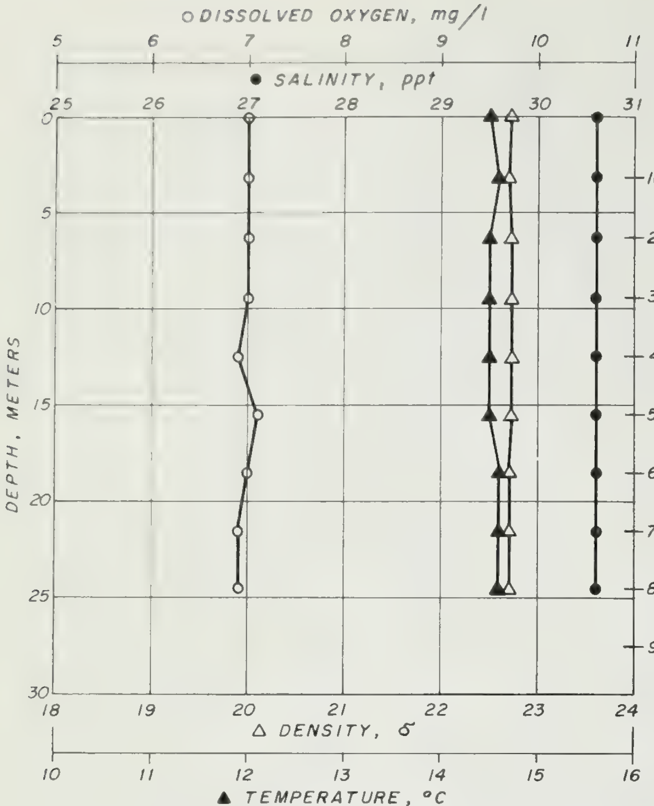
STATION BLOSSOM ROCK DATE 6/16/70 TIME 1549

DEPTH, FT 90 REFERENCE FIG. 4-39

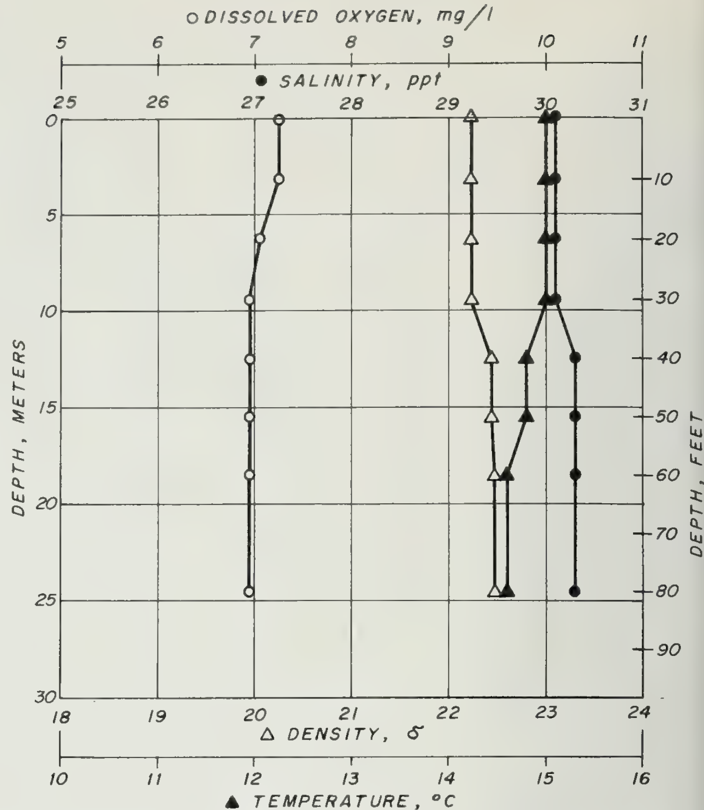


STATION 1500' OFF PIER 31 DATE 6/16/70 TIME 1719

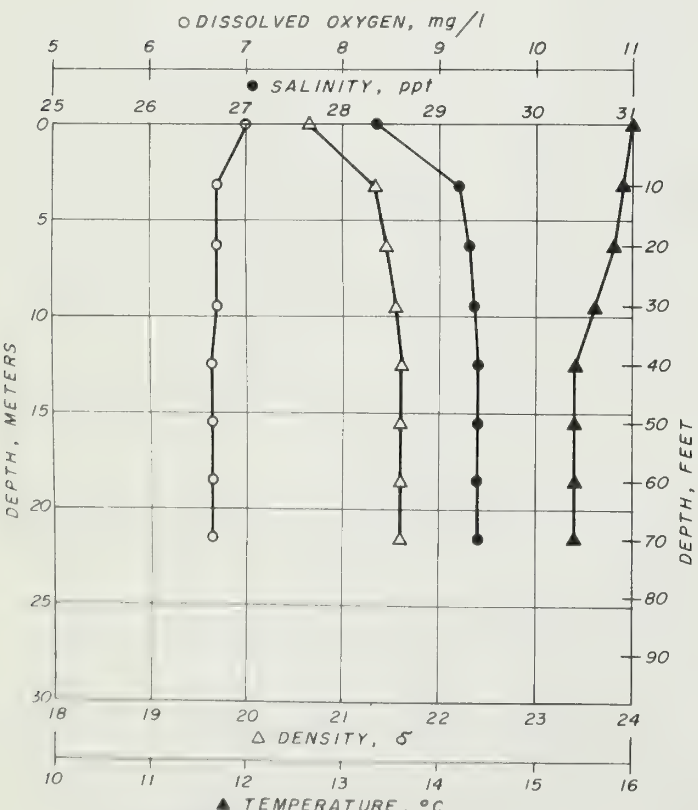
DEPTH, FT 65 REFERENCE FIG. 4-39



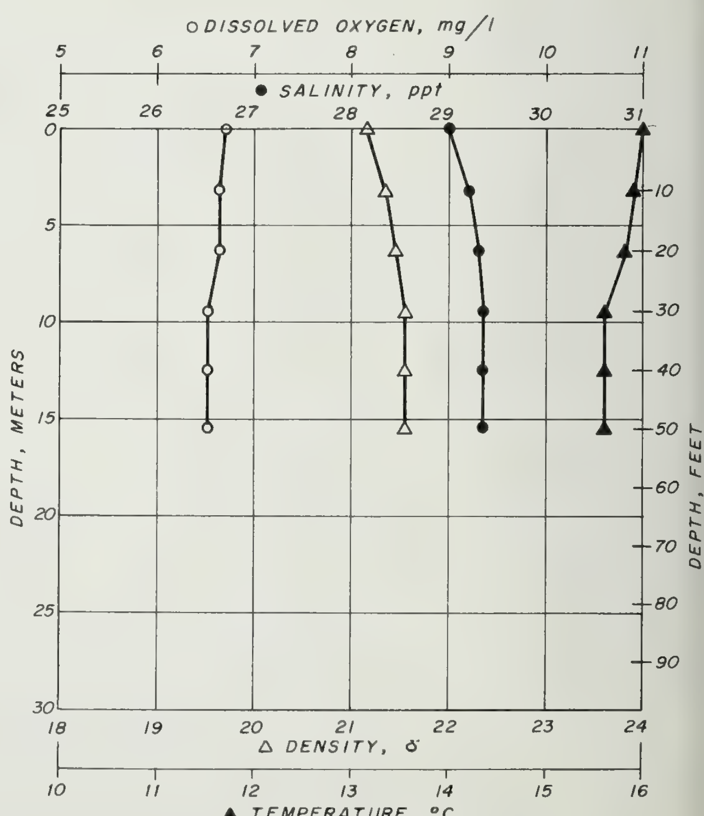
STATION BLOSSOM ROCK DATE 8/20/70 TIME 1319
DEPTH, FT 90 REFERENCE FIG. 4-40



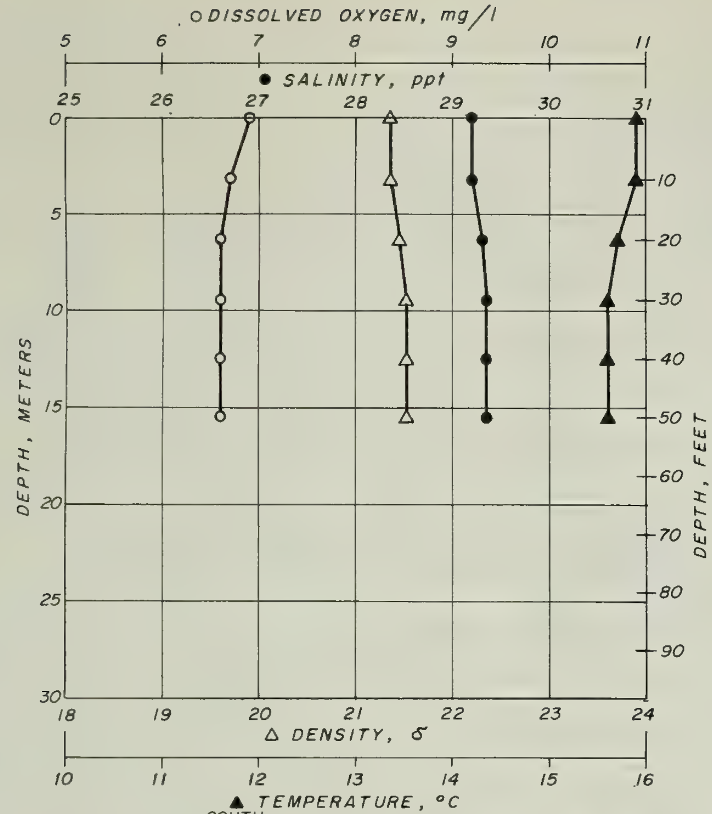
STATION W. OF YERBA BUENA DATE 8/20/70 TIME 1504
DEPTH, FT 105 REFERENCE FIG. 4-40



STATION BAY BRIDGE DATE 8/21/70 TIME 1240
DEPTH, FT 80 REFERENCE FIG. 4-40

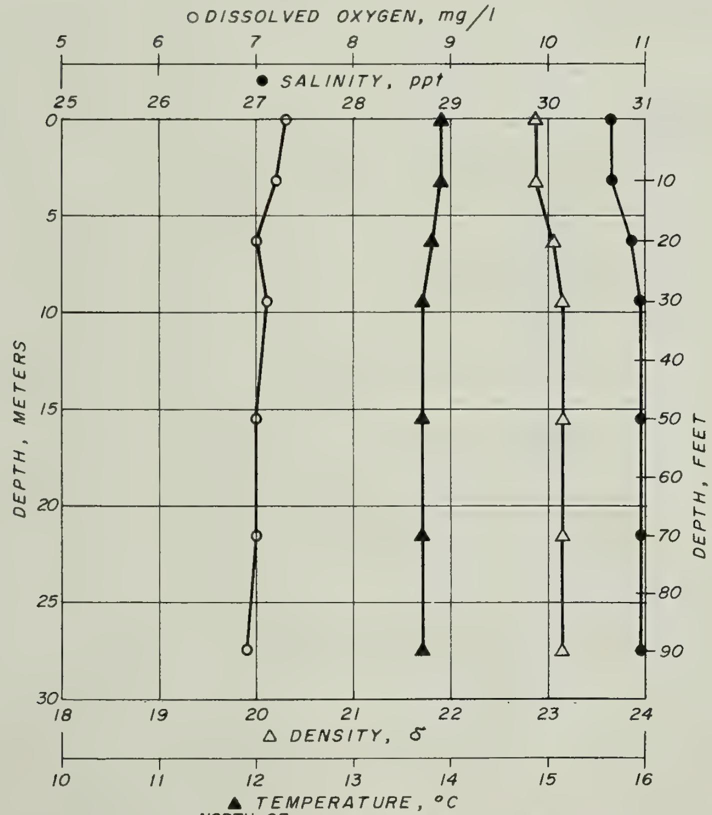


STATION SOUTH BAY DATE 8/21/70 TIME 1355
DEPTH, FT 60 REFERENCE FIG. 4-40



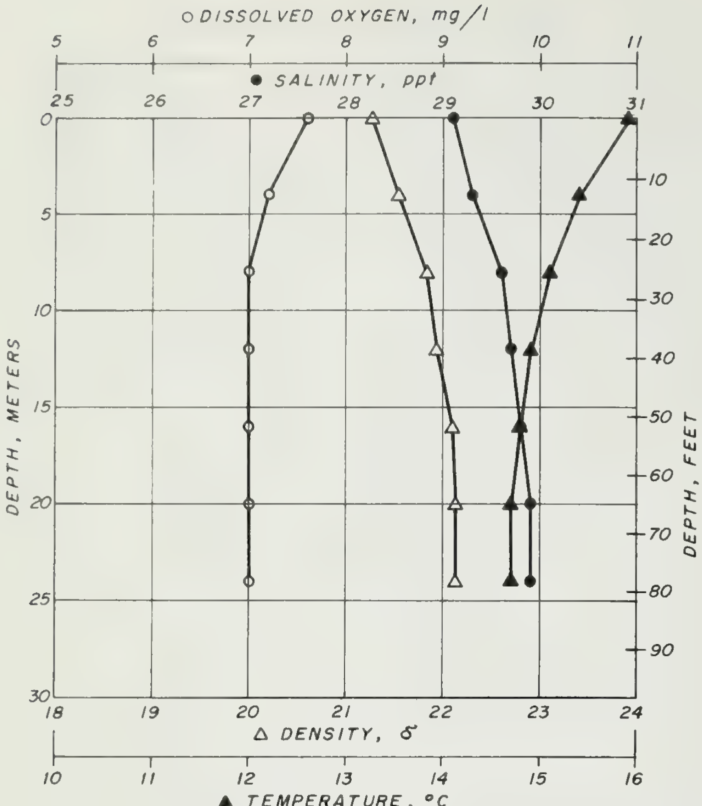
STATION SOUTH BAY DATE 8/21/70 TIME 1455

DEPTH, FT 60 REFERENCE FIG. 4-40

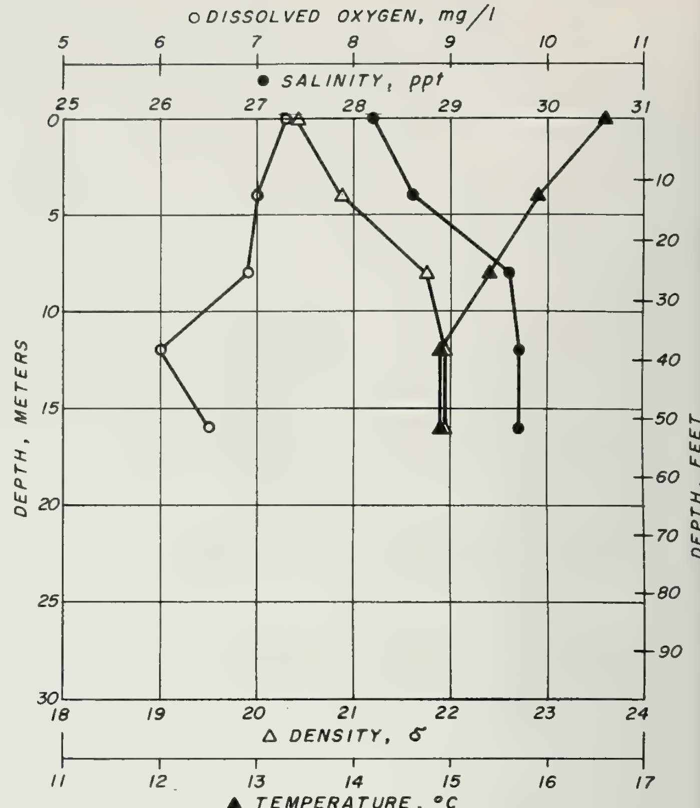


STATION NORTH OF ALCATRAZ DATE 8/21/70 TIME 1720

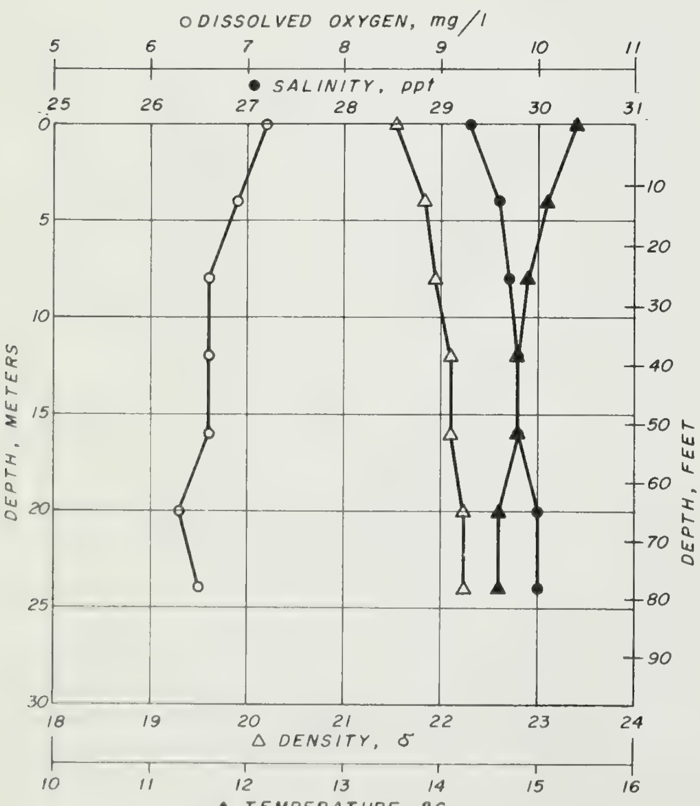
DEPTH, FT 100 REFERENCE FIG. 4-40



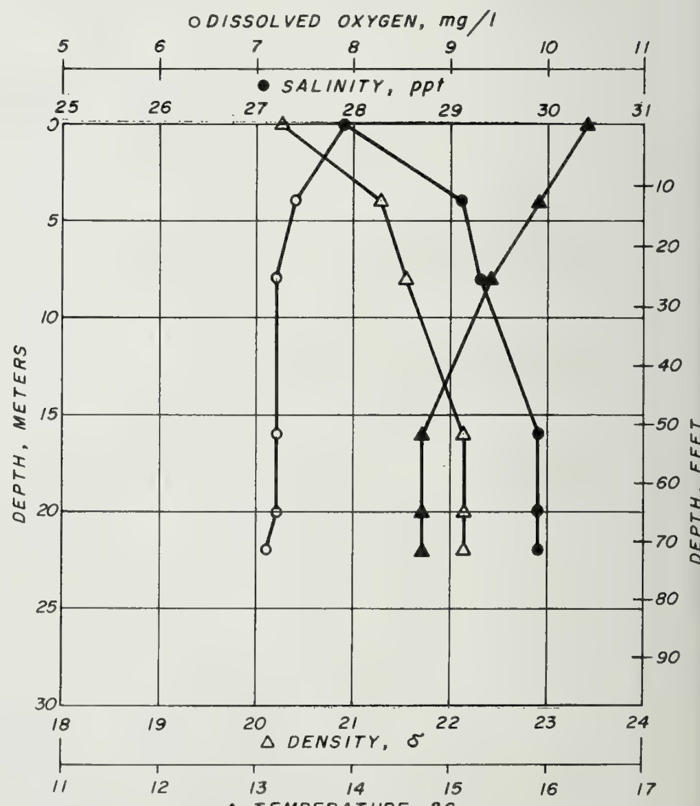
STATION 1500' OFF PIER 29 DATE 10/6/70 TIME 1233
DEPTH, FT 80 REFERENCE FIG. 4-41



STATION 1000' OFF PIER 5 DATE 10/6/70 TIME 1306
DEPTH, FT 60 REFERENCE FIG. 4-41



STATION 2500' OFF PIER 3 DATE 10/6/70 TIME 1359
DEPTH, FT 80 REFERENCE FIG. 4-41



STATION 2500' OFF FERRY BLDG. DATE 10/6/70 TIME 1409
DEPTH, FT 80 REFERENCE FIG. 4-41

San Francisco Bay Currents

Table 5. Summer Current Data, San Francisco Bay

Date Collected: June 16, 1970

Meter Type: Tsurumi TSK E-2 Current Meter

Station: Blossom Rock

Reference figure: 4-39

Water depth, feet: 90

Time PDST	1126		1256		1549	
Meter depth, feet	Speed, knots	Direction[a]	Speed, knots	Direction[a]	Speed, knots	Direction[a]
0	0.71	270	1.39	285	0.76	270
5	0.52	265	1.28	280	--	-
10	0.29	285	1.21	285	0.52	255
20	0.33	285	1.19	285	0.39	060
30	0.34	290	1.26	285	0.33	175
40	0.27	295	0.85	285	0.52	305
50	0.26	315	0.75	255	0.35	175
60	0.24	020	0.66	245	0.33	115
70	0.65	070	0.57	235	0.47	145
80	0.49	055	0.63	255	0.46	165

[a]Direction of movement in degrees measured clockwise from true north.

Table 6. Tidal Currents, Central San Francisco Bay

Station No.[a]	Observations			Currents					
				Flood			Ebb		
	Period	Depth, feet	Total days	Direction[b]	Velocity, knots		Direction[b]	Velocity, knots	
					Mean	Max		Mean	Max
9	Feb. 6-11, 1952	8	4	156	1.59	2.1	337	1.87	2.4
		30	4	158	1.49	1.8	332	1.88	2.5
		55	4	176	1.48	1.8	347	1.68	2.5
10	Feb. 6-11, 1952	8	3	164	1.56	2.3	1	1.52	2.5
		23	4	144	1.69	2.7	343	1.46	2.3
		40	4	158	1.44	1.7	326	1.27	1.9
13	Feb. 13-17, 1952	8	4	160	2.48	2.7	320	2.34	2.7
		26	4	140	1.87	1.8	322	1.98	2.1
		46	4	132	1.32	1.2	323	1.31	1.4
14	Feb. 13-17, 1952	8	4	182	2.06	2.2	344	1.95	2.0
		27	4	145	2.42	2.3[c]	331	2.15	2.2
		49	4	165	1.73	2.1	348	1.37	1.4
15	Feb. 13-17, 1952	8	3	150	1.70	1.4[c]	335	2.39	2.4
		18	4	134	1.66	1.6[c]	325	2.14	2.4
		30	4	148	1.54	1.7	348	1.62	2.0
17	April 5-8, 1952	8	3	138	1.51	2.0	345	2.24	2.4
		27	1	113	1.47	1.5	303	2.02	2.2
		48	3	118	1.39	1.8	312	1.46	1.5
18	April 9-13, 1952	8	4	180	1.74	2.0	338	1.84	2.4
		18	4	165	1.46	1.8	334	1.47	1.9
		31	4	180	0.78	1.2	10	0.64	1.1
22	March 27-31, 1952	8	4	141	1.33	1.6	306	2.57	3.2
		39	4	144	1.90	2.0	333	2.13	3.8
		73	4	160	1.67	2.4	342	1.50	2.6
23	March 25-29, 1952	8	4	209	1.43	2.0	329	2.49	3.3
		63	4	122	1.70	2.4	313	1.85	3.0
		120	4	141	1.86	2.6	319	1.38	3.1
24	March 26-30, 1952	8	4	146	1.38	2.0	309	2.74	3.3
		49	4	108	1.62	2.1	295	1.71	3.0
		92	4	129	1.39	1.7	304	0.69	1.6
26	March 31-April 4, 1952	8	4	144	1.73	2.0	340	1.92	1.7[c]
		17	4	137	1.39	1.8	320	1.51	1.3[c]
		28	4	151	1.22	1.2[c]	340	1.02	0.9[c]
27	March 31-April 4, 1952	8	4	140	1.33	1.7	331	1.64	1.4[c]
		21	4	140	1.05	1.5	318	1.07	0.9[c]
28	April 1-4, 1952	6	2	Insufficient observations					
29	April 21-26, 1952	8	5	130	1.31	1.9	325	1.32	1.9
		14	5	101	0.99	1.4	297	1.15	1.6
		22	5	114	0.91	1.3	288	0.85	1.3
30	April 1-5, 1952	8	4	114	1.11	1.4	297	1.61	1.6[c]
		14	4	114	1.13	1.3	312	1.44	1.6
		22	3	131	0.99	0.9[c]	306	1.06	1.2
32	Feb. 20-24, 1952	8	4	149	0.91	2.0	360	2.26	3.4
		32	4	109	1.11	1.8	282	1.46	3.1
		59	4	127	1.03	1.8	279	0.99	2.3
33	Feb. 20-24, 1952	8	4	142	1.02	2.0	319	2.27	3.2
		31	4	131	0.84	1.4	298	1.45	2.8
		71	4	97	0.95	1.3	246	1.23	2.1

Continued on next page

Table 6. Continued

Station No.[a]	Observations			Currents					
				Flood			Ebb		
	Period	Depth, feet	Total days	Direction[b]	Velocity, knots		Direction[b]	Velocity, knots	
					Mean	Max		Mean	Max
34	Feb. 20-24, 1952	8	4	94	0.68	2.0	274	2.37	3.9
		43	4	97	0.68	1.4	243	1.52	2.6
		80	4	45	1.01	1.5	229	1.46	2.3
35	Aug. 25-29, 1953	8	4	91	1.27	2.4	316	1.85	2.6
		56	4	68	1.27	2.2	271	1.52	2.7
36	Sept. 1-5, 1953	8	5	72	1.52	1.7	275	1.54	2.0
		21	5	83	1.52	1.9	279	1.43	1.8
	Sept. 9-10, 1953	44	2	73	0.88	1.4	249	0.96	1.4
37	March 21-25, 1952	8	4	93	2.20	3.4	272	2.40	3.2
		27	4	84	2.18	3.3	252	2.08	3.0
		48	4	111	1.54	2.4	283	1.32	2.4
38	March 6-8 & 12-18, 1952	8	9	75	2.60	3.2	267	2.67	3.3
	March 6-10, 1952	27	4	46	2.06	2.7	234	2.22	2.9
		48	4	72	1.98	2.4	257	1.88	2.6
39	March 13-18, 1952	8	5	66	1.82	2.3	284	2.40	2.6
		46	5	79	1.95	2.0	266	1.93	1.9[c]
		87	5	69	1.80	2.2	257	1.74	2.3
40	March 13-18, 1952	8	5	66	1.55	2.3	261	2.24	2.7
		67	5	58	2.10	2.3	242	1.90	2.0
		128	5	38	1.57	2.0	271	1.58	2.6
42	Feb. 26 - March 2, 1952	8	5	206	2.71	2.7[c]			3.1
				56	1.96		252	1.92	
		75	5	59	1.83	2.6	232	1.57	2.4
		145	5	26	2.13	2.7	207	1.29	2.4
43	Feb. 26 - March 2, 1952	8	5	152	2.06	2.5			2.9
				68	1.06		300	1.38	
		36	5	168	1.21	1.8			2.0
				46	1.55		257	1.42	
		67	5	18	0.85	2.5	240	1.47	1.7
44	Feb. 26 - March 2, 1952	8	4	151	1.54	2.0			2.3
				108	1.69		310	1.57	
		16	4	114	1.50	1.9	299	1.40	1.7
		27	4	128	1.09	1.5	286	1.07	1.4
45	Feb. 26 - March 1, 1952	8	4	163	1.32	1.7			1.0
				137	1.37		309	0.72	
		14	4	124	1.06	1.6	301	0.79	1.2
		22	4	112	0.83	1.3	261	0.86	1.2
52	March 7-10, 1952	8	3	62	0.92	1.6	242	1.32	2.7
		65	3	26	1.39	2.1	236	1.13	2.2
		125	2			Insufficient observations			
53	March 7-9, 1952	6	2	74	0.91	1.0	(225)	0.55	1.0
54	Aug. 24-29, 1953	8	5	8	1.53	2.2	–	–	0.6
		24	5	2	1.56	2.4	–	–	0.5
55	Aug. 18-24, 1953	8	6	37	2.16	2.8	253	1.70	3.2
		31	6	40	1.91	2.4	209	1.52	2.4
	Sept. 9-11, 1953	50	2	39	2.02	2.4	258	1.38	1.6
56	Aug. 11-17, 1953	8	6	7	1.01	1.2	218	2.13	2.4
		76	6	356	1.20	1.1[c]	178	2.03	2.2

Continued on next page

Table 6. Continued

Station No.[a]	Observations			Currents					
				Flood			Ebb		
	Period	Depth, feet	Total days	Direction[b]	Velocity, knots		Direction[b]	Velocity, knots	
					Mean	Max		Mean	Max
57	March 6-10, 1952	8	5	22	2.93	3.4	257	2.30	3.0
		53	5	34	2.90	3.3	236	2.23	2.9
		100	5	63	2.43	3.1	204	1.79	2.1
58	March 6-10, 1952	8	4	87	2.39	2.7	256	2.55	3.4
		43	4	67	2.01	2.3	260	2.15	3.1
		80	4	50	1.46	1.7	240	1.30	1.7
59	March 20 - April 24, 1952	8	35	70	2.54	4.3	256	2.34	4.0
		85	35	57	2.54	4.3	245	1.83	2.9
		165	35	55	1.89	3.6	231	1.86	3.0

[a]See Fig. 4-4.

[b]Direction of current movement, measured in degrees clockwise from true north.

Source: U.S. Coast & Geodetic Survey Report on Currents in San Francisco Bay, June 1955 (Unpublished).

[c]As reported by USC & GS.

Table 7. Mass Displacement Vectors, Central San Francisco Bay

Station[a]	Current measurement[b]		Displacement vector[c]	
	Date	Depth, feet	Length, nautical miles	Bearing, degrees[d]
9	Feb. 8-9, 1952	30	7.7	86
9	Feb. 10-11, 1952	8	5.2	29
		30	6.9	80
		55	4.3	259
10	Feb. 8-9, 1952	8	1.2	241
		23	6.4	99
		40	4.4	222
13	Feb. 14-15, 1952	8	3.5	279
		26	0.8	128
		46	3.7	103
13	Feb. 16-17, 1952	8	9.6	256
		26	0.7	106
		46	2.8	113
14	Feb. 14-15, 1952	8	4.7	347
		27	4.5	155
		49	8.3	168
14	Feb. 16-17, 1952	8	5.4	267
		27	4.3	137
		49	5.6	164
17	Apr. 5-6, 1952	8	9.3	14
		48	4.5	77
17	Apr. 7-8, 1952	8	13.3	45
		48	1.5	105
22	Mar. 28-29, 1952	8	15.4	290
		39	1.0	21
		73	8.8	113
22	Mar. 30-31, 1952	8	13.9	289
		39	0.8	137
		73	5.9	137
23	Mar. 26-27, 1952	8	22.8	294
		63	0.7	358
23	Mar. 28-29, 1952	8	17.8	300
		63	3.9	179
24	Mar. 27-28, 1952	8	14.5	293
		49	4.4	96
24	Mar. 29-30, 1952	8	16.1	301
33	Feb. 21-22, 1952	8	12.3	289
		38	3.6	289
		71	3.9	212
33	Feb. 23-24, 1952	8	15.6	292
		38	8.1	319
		71	2.3	218
32	Feb. 21-22, 1952	8	13.8	46
		32	7.5	135
		59	8.7	178
32	Feb. 23-24, 1952	8	28.7	17
		32	4.0	304
		59	4.3	159

Continued on next page

Table 7. Continued

Station[a]	Current measurement[b]		Displacement vector[c]	
	Date	Depth, feet	Length, nautical miles	Bearing, degrees[d]
34	Feb. 23-24, 1952	8	22.9	260
		43	12.3	247
		80	4.6	247
35	Aug. 25-26, 1953	8	10.6	359
		56	4.9	359
35	Aug. 28-29, 1953	8	8.7	351
		56	1.8	296
36	Sept. 1-2, 1953	8	7.0	334
		21	2.4	335
36	Sept. 4-5, 1953	8	4.3	343
		21	2.8	354
37	Mar. 21-22, 1952	8	11.4	277
		27	6.0	144
		48	5.5	109
37	Mar. 24-25, 1952	8	9.6	247
		37	5.7	204
		48	4.2	98
38	Mar. 6-7, 1952	8	14.5	264
		27	6.3	289
		48	4.3	58
38	Mar. 14-15, 1952	8	6.8	333
56	Aug. 12-13, 1953	8	12.6	191
		76	10.1	170
56	Aug. 15-16, 1953	8	10.7	208
		76	9.5	165
57	Mar. 6-7, 1952	8	8.1	321
		53	7.2	2
		100	1.2	317
58	Mar. 6-7, 1952	8	4.3	243
		43	1.8	200
		80	6.2	0
58	Mar. 9-10, 1952	8	4.4	202
59	Mar. 25-26, 1952	8	17.0	352
		85	6.7	71
		165	7.0	339
59	Mar. 27-28, 1952	8	20.7	29
		85	10.8	58
		165	11.8	338

[a]See Fig. 4-4.

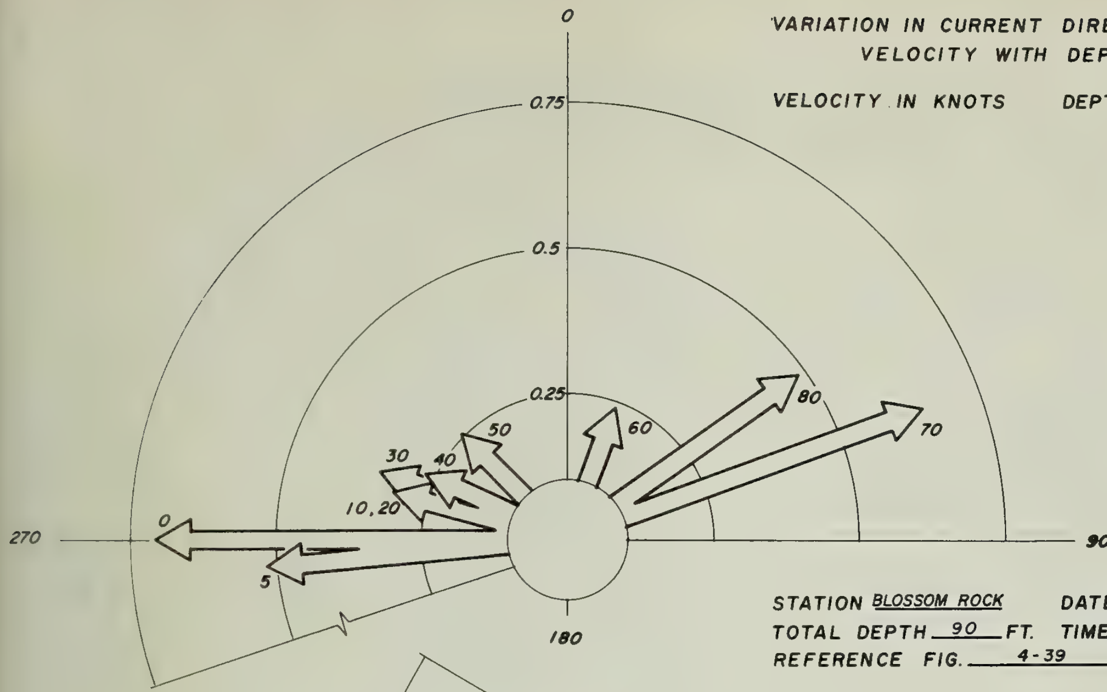
[b]Current measurements taken by USC&GS in 1952, 1953, and 1954 (unpublished)

[c]Vectors are the summation of hourly current vectors at the station and depth indicated over one complete 25-hour tidal cycle.

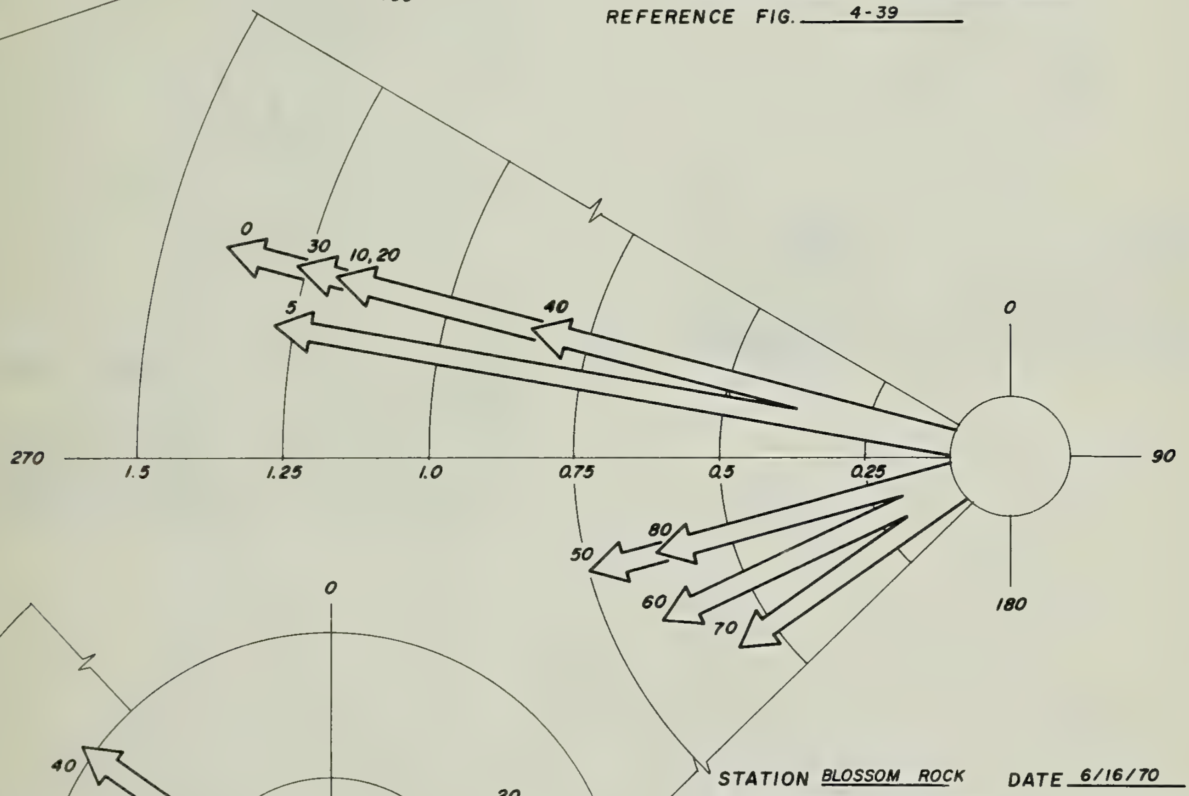
[d]Direction of current movement, measured in degrees clockwise from True North.

VARIATION IN CURRENT DIRECTION AND VELOCITY WITH DEPTH

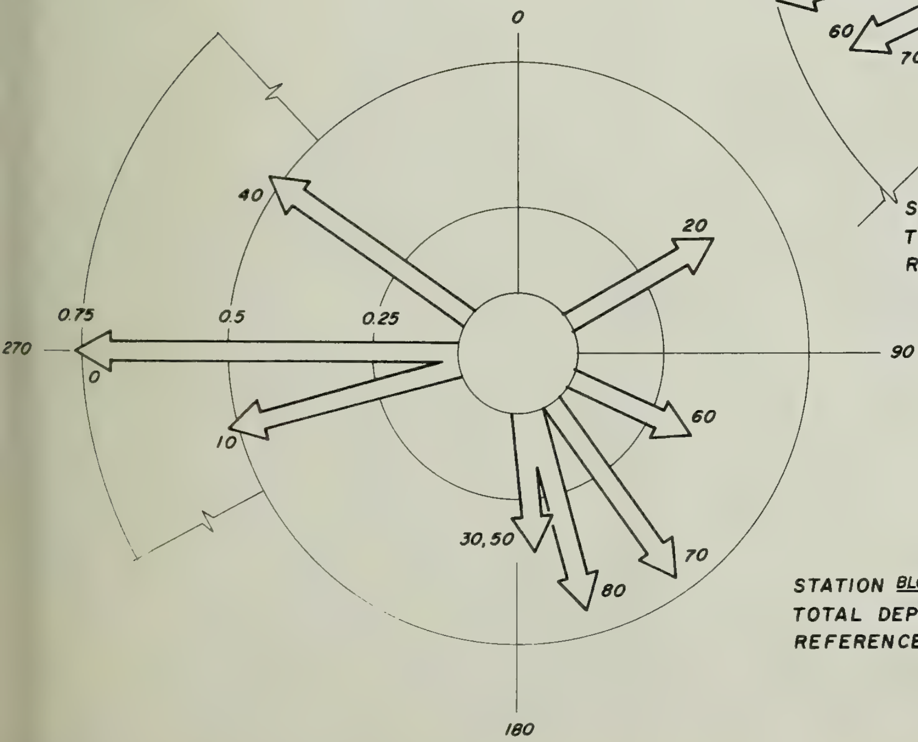
VELOCITY IN KNOTS DEPTH IN FEET



STATION BLOSSOM ROCK DATE 6/16/70
TOTAL DEPTH 90 FT. TIME 1126 HRS.
REFERENCE FIG. 4-39

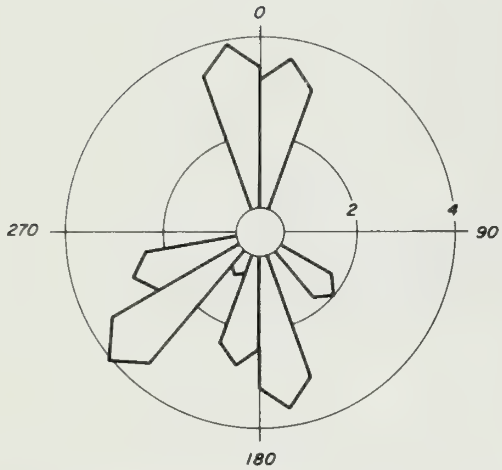


STATION BLOSSOM ROCK DATE 6/16/70
TOTAL DEPTH 90 FT. TIME 1256 HRS.
REFERENCE FIG. 4-39

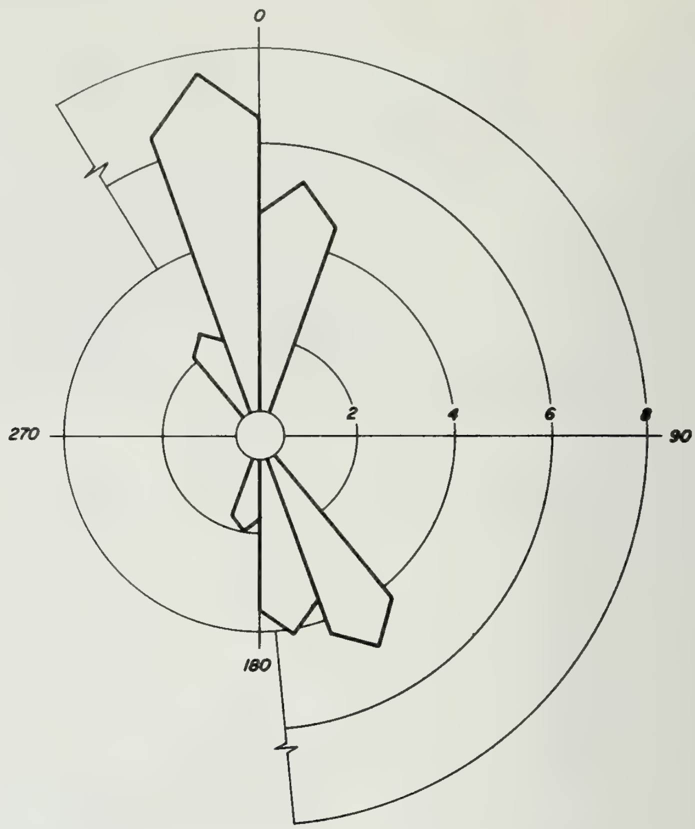


STATION BLOSSOM ROCK DATE 6/16/70
TOTAL DEPTH 90 FT. TIME 1549 HRS.
REFERENCE FIG. 4-39

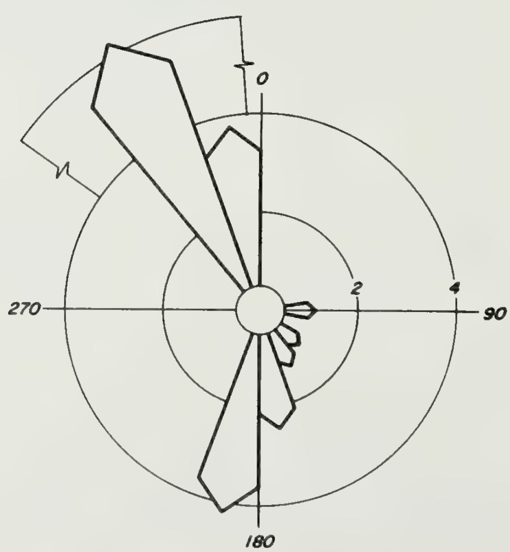
ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 9 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 2.4
DATE FEB. 8-9, 1952 — MEAN 0.99
REFERENCE FIG. 4-4 — MIN. 0.3
PERIOD OF OBSERVATION 1000 FEB. 8 - 1100 FEB. 9

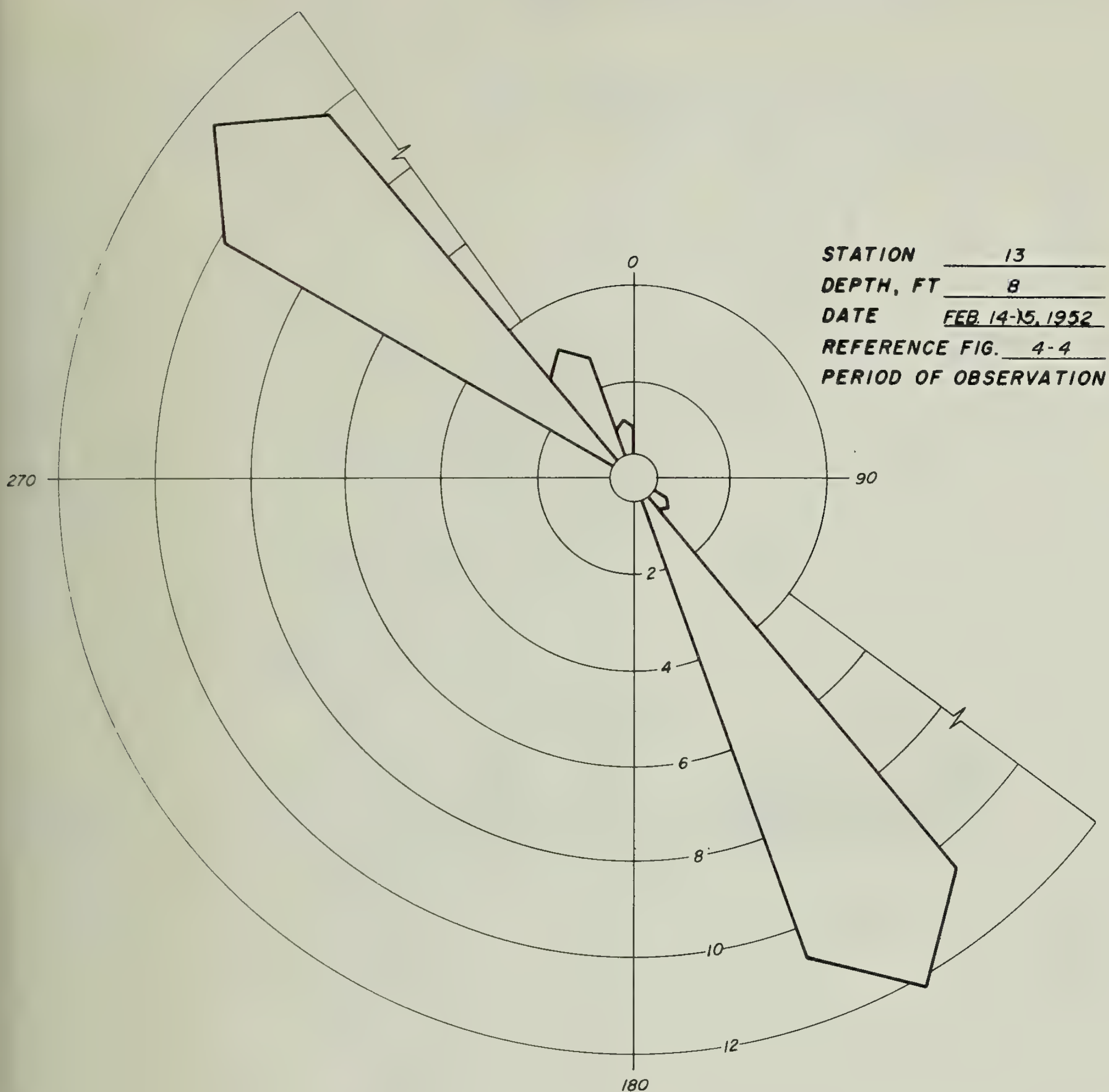


STATION 9 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 2.4
DATE FEB. 10-11, 1952 — MEAN 1.08
REFERENCE FIG. 4-4 — MIN. 0.3
PERIOD OF OBSERVATION 1100 FEB. 10 - 1200 FEB. 11



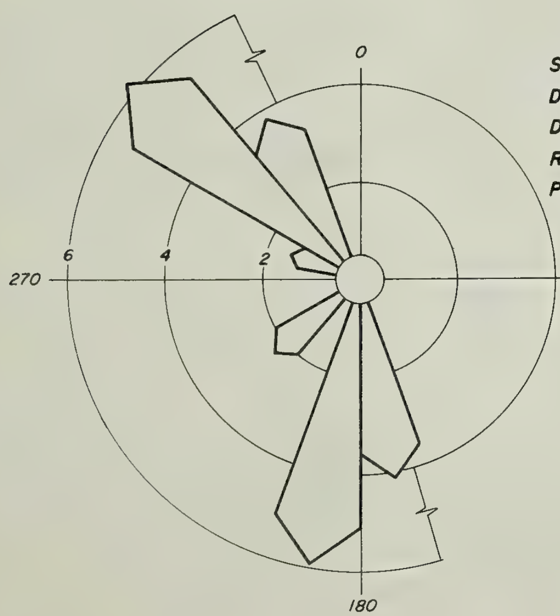
STATION 10 — CURRENT, KNOTS
DEPTH, FT 8 — MAX. 2.3
DATE FEB. 8-9, 1952 — MEAN 0.85
REFERENCE FIG. 4-4 — MIN. 0.2
PERIOD OF OBSERVATION 1100 FEB. 8 - 1200 FEB. 9

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 13
DEPTH, FT 8
DATE FEB. 14-15, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0200 FEB. 14 - 0300 FEB. 15

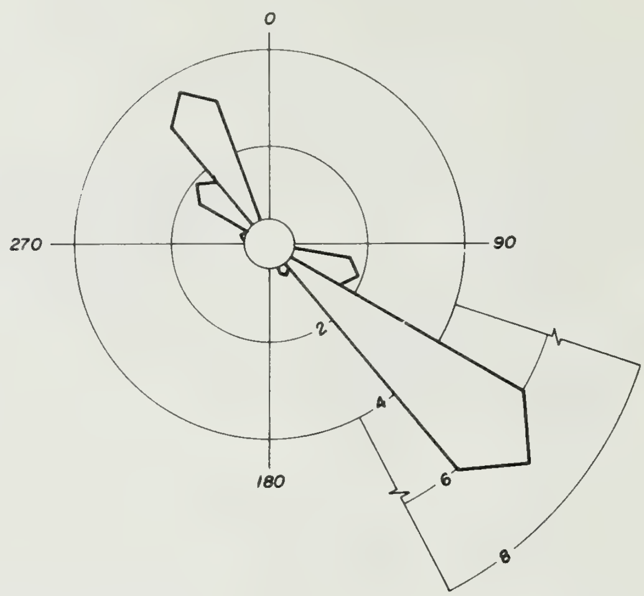
CURRENT, KNOTS
MAX. 2.4
MEAN 1.22
MIN. 0.2



STATION 13
DEPTH, FT 8
DATE FEB. 16-17, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0300 FEB. 16 - 0400 FEB. 17

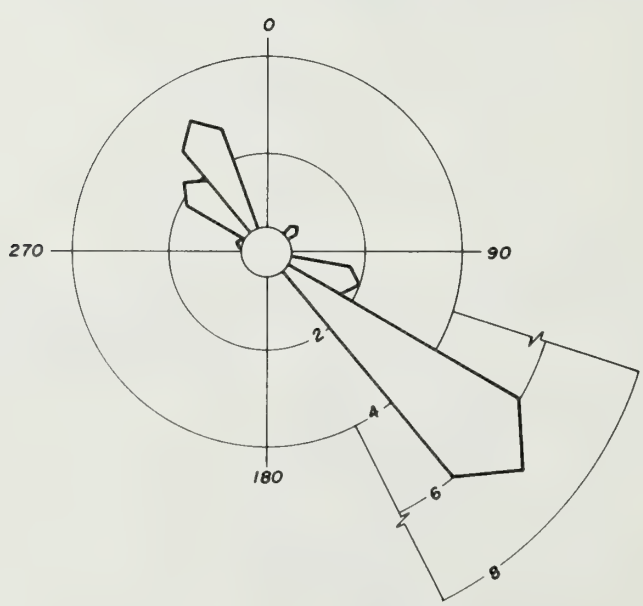
CURRENT, KNOTS
MAX. 2.7
MEAN 0.99
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	13	CURRENT, KNOTS	
DEPTH, FT	46	MAX.	1.3
DATE	FEB. 14-15, 1952	MEAN	0.68
REFERENCE FIG.	4-4	MIN.	0.3

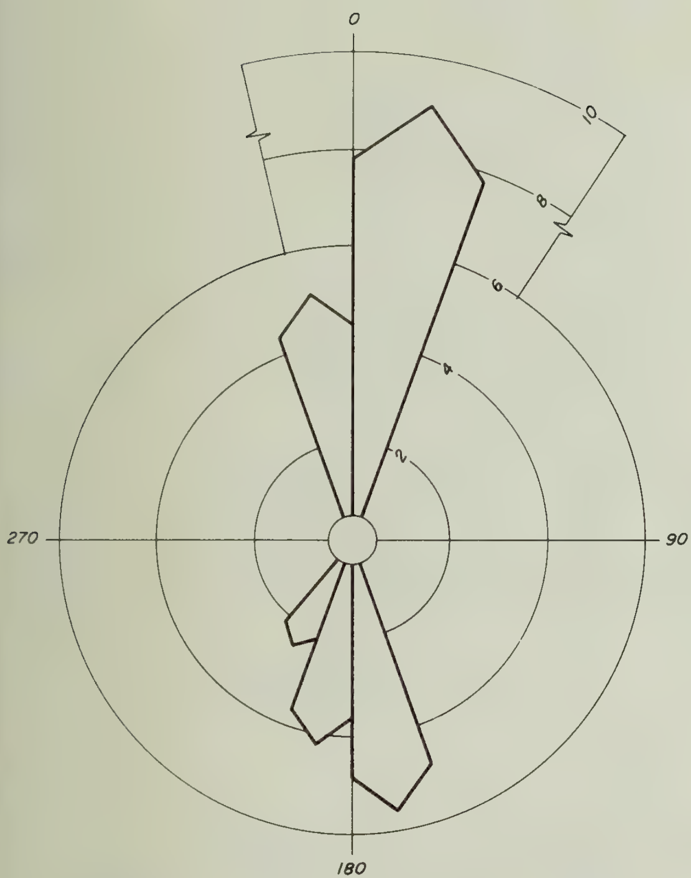
PERIOD OF OBSERVATION 0200 FEB. 14 - 0300 FEB. 15



STATION	13	CURRENT, KNOTS	
DEPTH, FT	46	MAX.	1.6
DATE	FEB. 16-17, 1952	MEAN	0.66
REFERENCE FIG.	4-4	MIN.	0.3

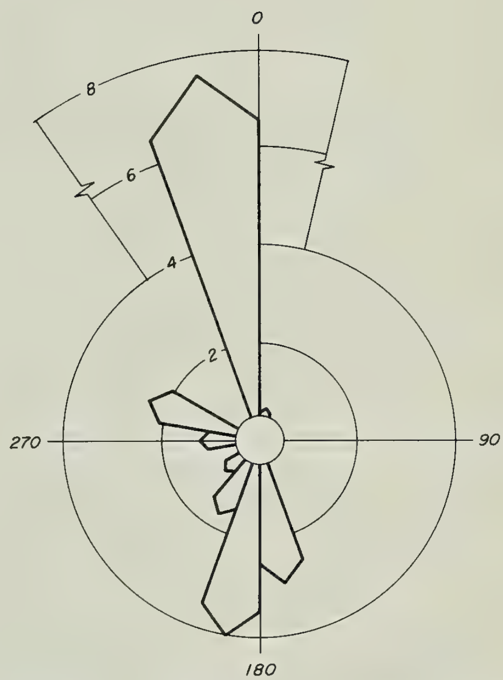
PERIOD OF OBSERVATION 0300 FEB. 16 - 0400 FEB. 17

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	14	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.0
DATE	FEB. 14-15, 1952	MEAN	1.08
REFERENCE FIG.	4-4	MIN.	0.2

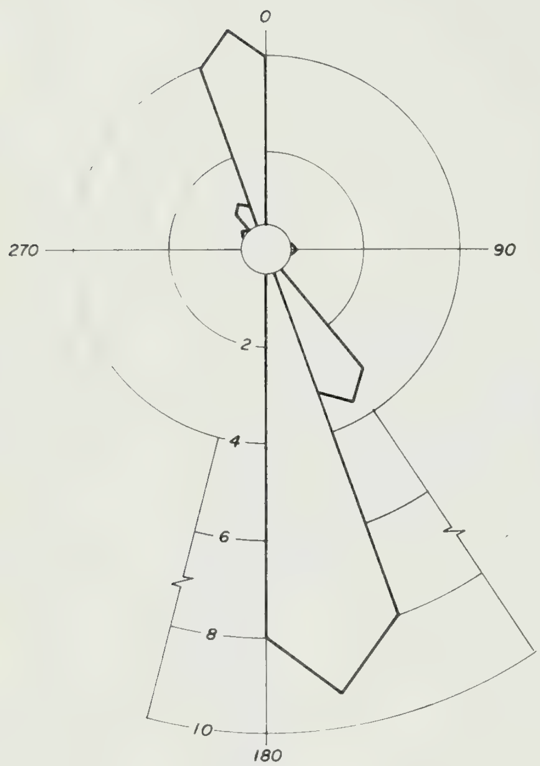
PERIOD OF OBSERVATION 0200 FEB. 14-0300 FEB. 15



STATION	14	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.0
DATE	FEB. 16-17, 1952	MEAN	0.84
REFERENCE FIG.	4-4	MIN.	0.2

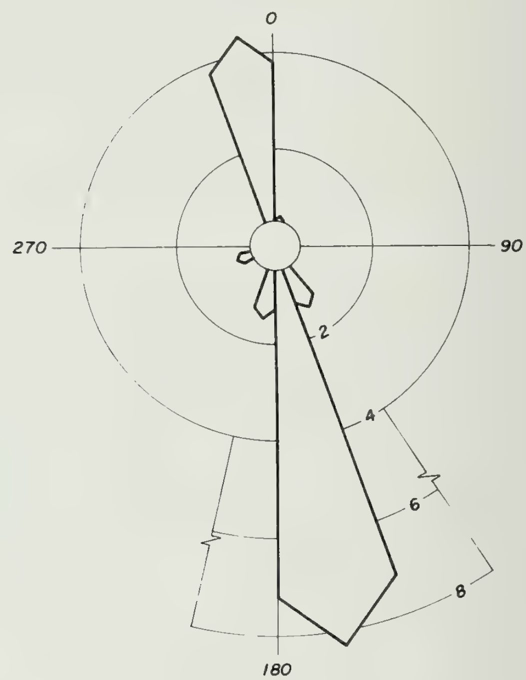
PERIOD OF OBSERVATION 0300 FEB. 16-0400 FEB. 17

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	14	CURRENT, KNOTS	
DEPTH, FT	49	MAX.	1.4
DATE	FEB. 14-15, 1952	MEAN	0.84
REFERENCE FIG.	4-4	MIN.	0.2

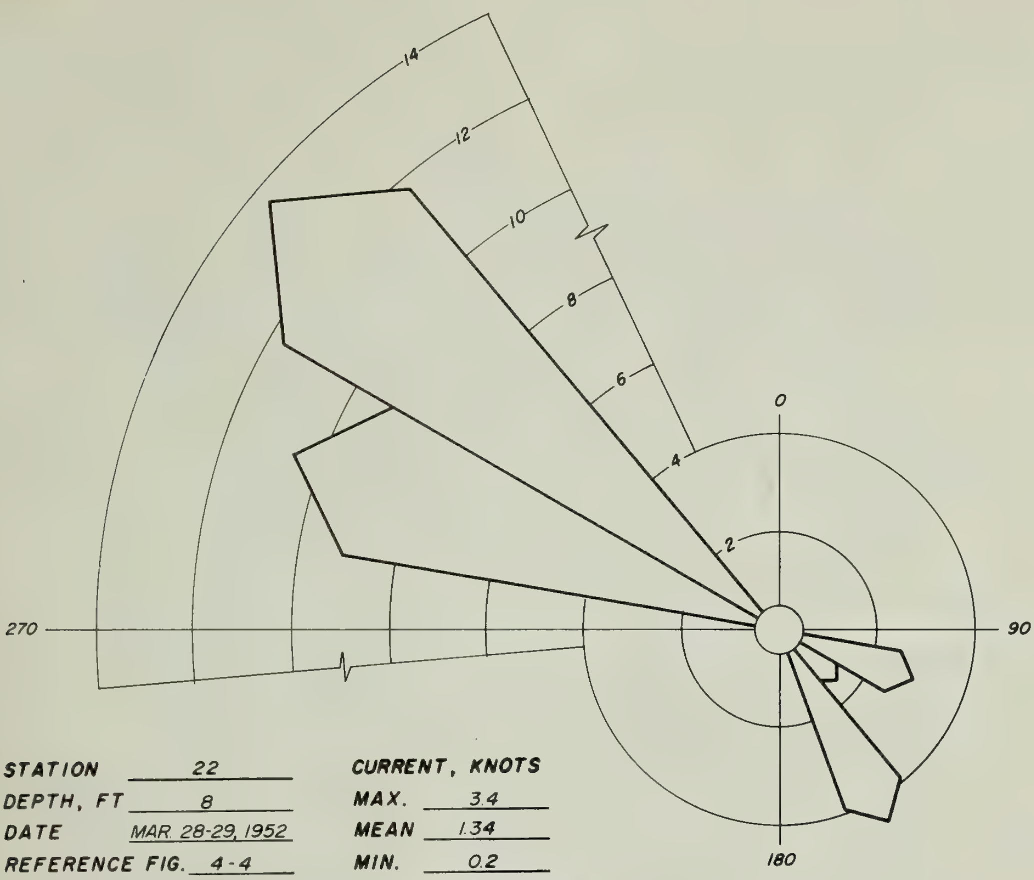
PERIOD OF OBSERVATION 0200 FEB. 14-0300 FEB. 15



STATION	14	CURRENT, KNOTS	
DEPTH, FT	49	MAX.	1.3
DATE	FEB. 16-17, 1952	MEAN	0.74
REFERENCE FIG.	4-4	MIN.	0.2

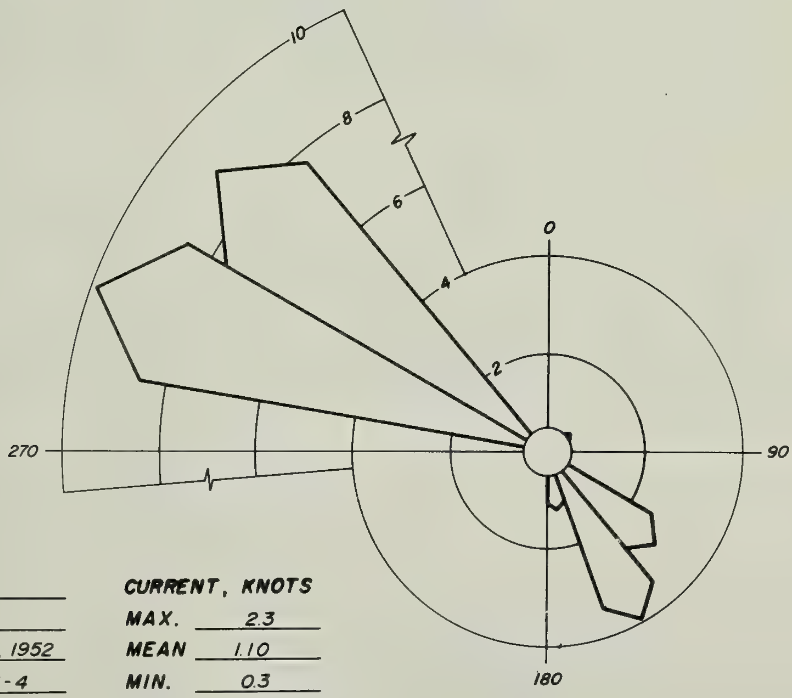
PERIOD OF OBSERVATION 0300 FEB. 16-0400 FEB. 17

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 22
DEPTH, FT 8
DATE MAR. 28-29, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0100 MAR. 28-0200 MAR. 29

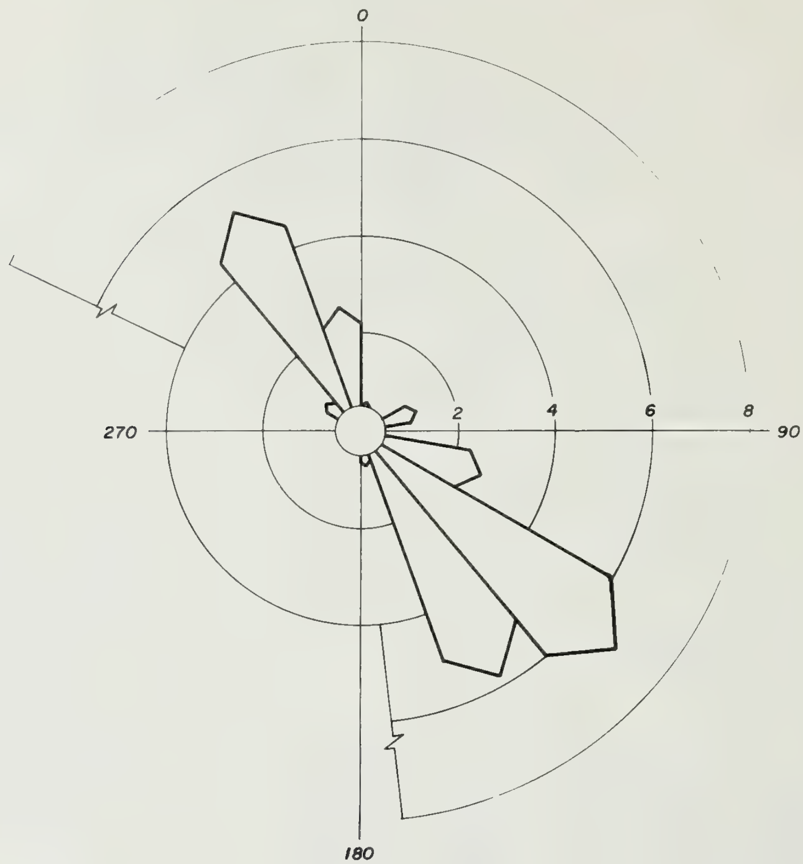
CURRENT, KNOTS
MAX. 3.4
MEAN 1.34
MIN. 0.2



STATION 22
DEPTH, FT 8
DATE MAR. 30-31, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1600 MAR. 30-1700 MAR. 31

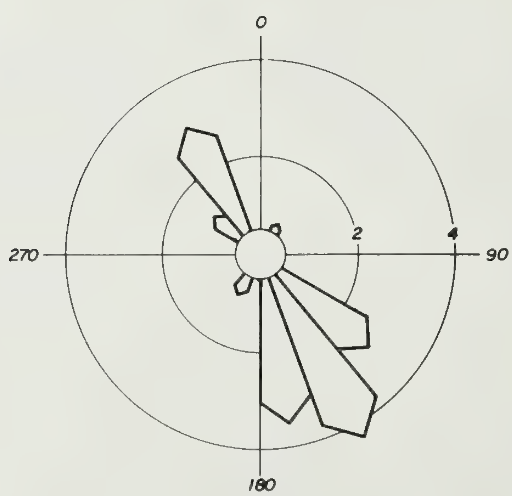
CURRENT, KNOTS
MAX. 2.3
MEAN 1.10
MIN. 0.3

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	22	CURRENT, KNOTS	
DEPTH, FT	73	MAX.	2.6
DATE	MAR. 28-29, 1952	MEAN	1.1
REFERENCE FIG.	4-4	MIN.	0.2

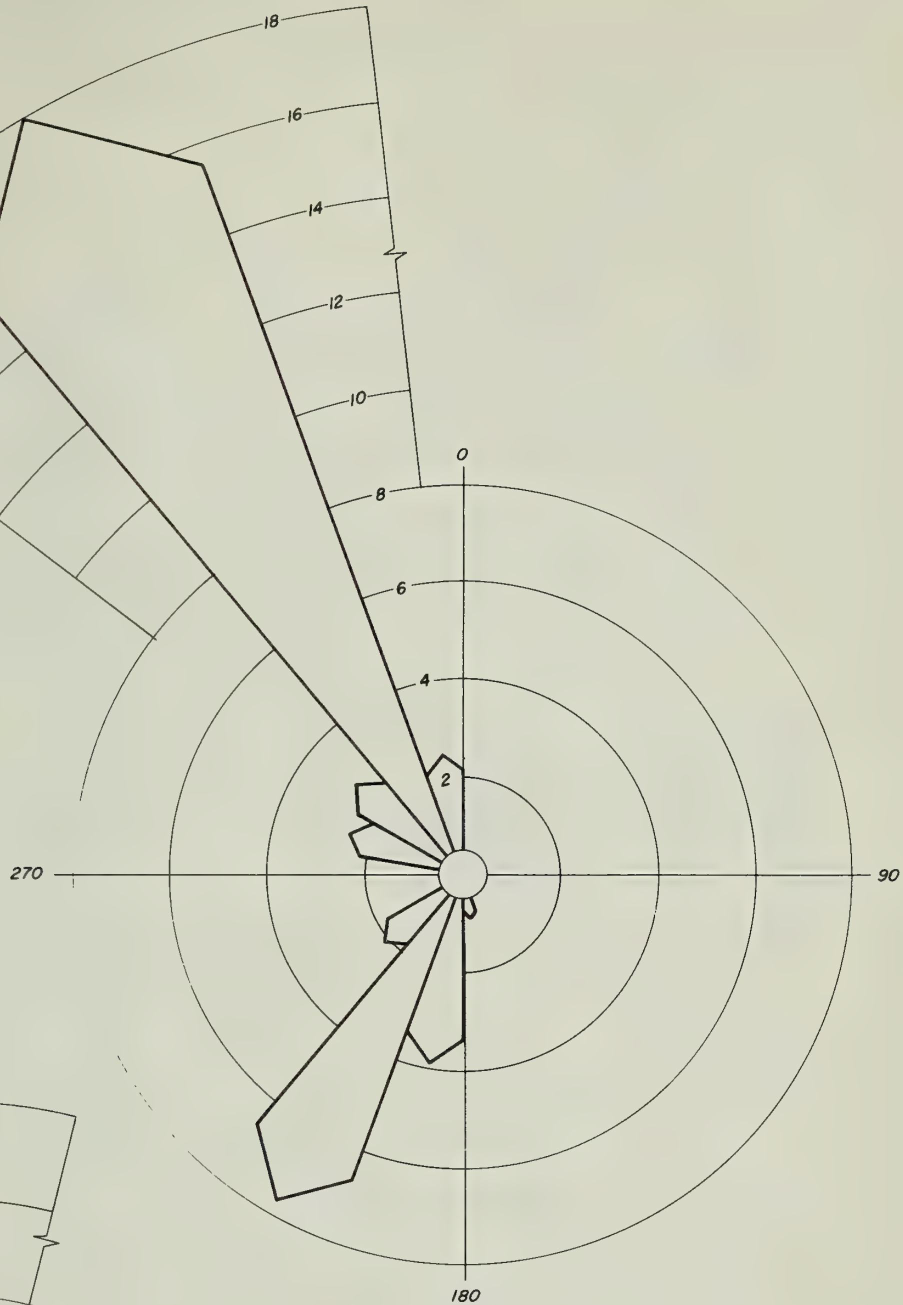
PERIOD OF OBSERVATION 0100 MAR. 28 - 0200 MAR. 29



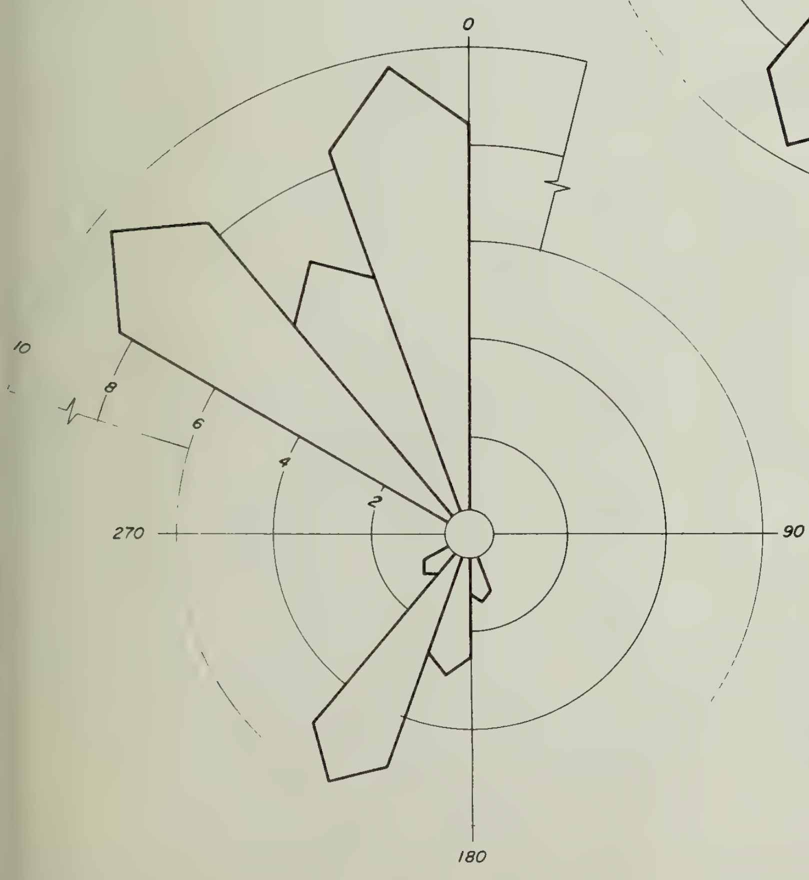
STATION	22	CURRENT, KNOTS	
DEPTH, FT	73	MAX.	1.8
DATE	MAR. 30-31, 1952	MEAN	0.72
REFERENCE FIG.	4-4	MIN.	0.3

PERIOD OF OBSERVATION 1600 MAR. 30 - 1700 MAR. 31

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)

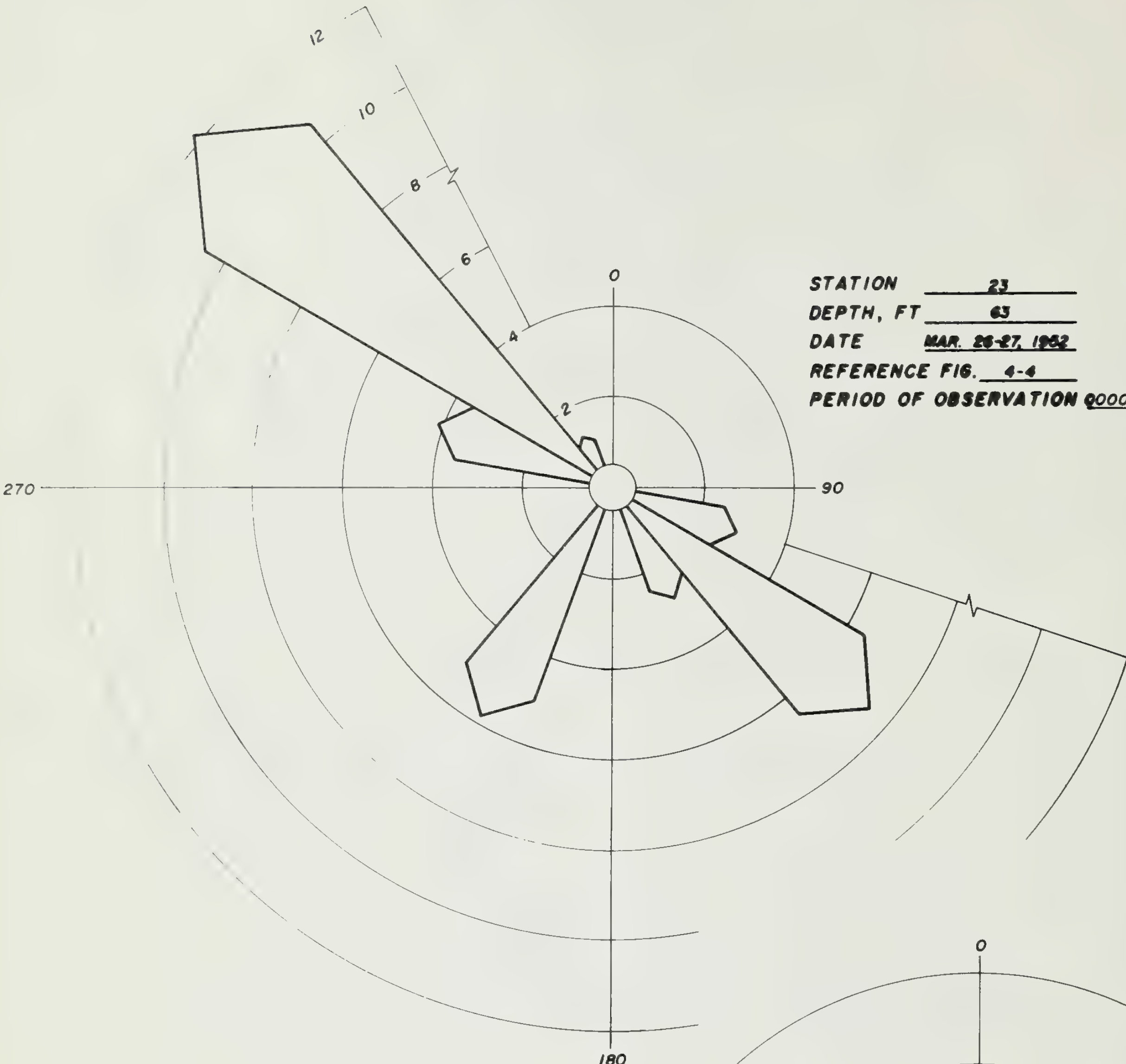


STATION	23	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.9
DATE	MAR. 26-27, 1952	MEAN	1.63
REFERENCE FIG.	4-4	MIN.	0.4
PERIOD OF OBSERVATION	0000 MAR. 26-0100 MAR. 27		



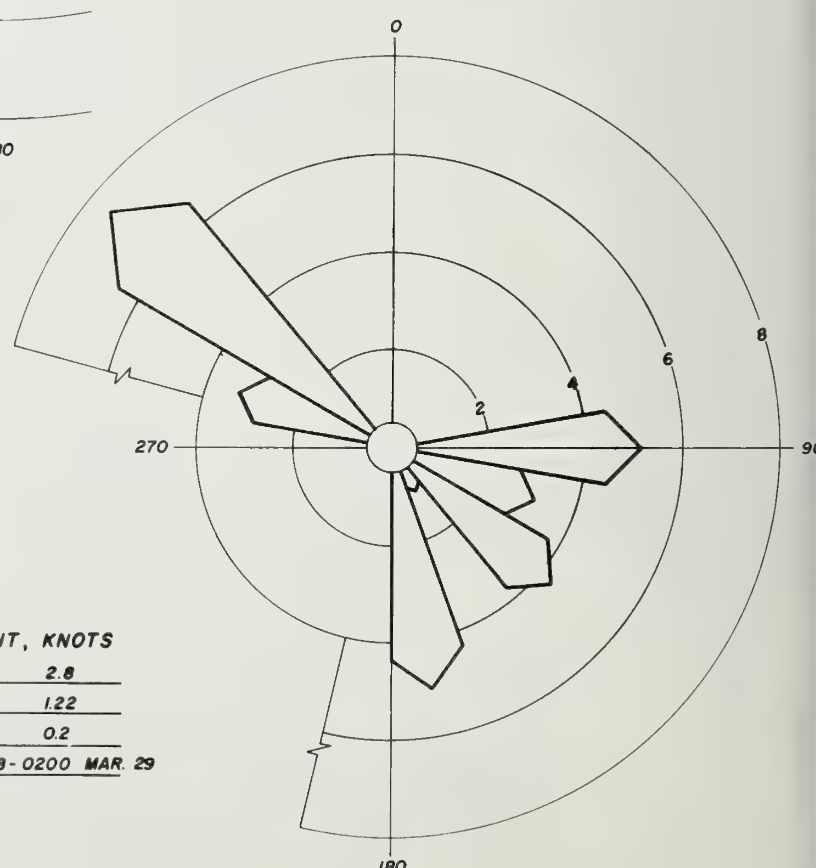
STATION	23	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	3.3
DATE	MAR. 28-29, 1952	MEAN	1.51
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	0100 MAR. 28-0200 MAR. 29		

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	23	CURRENT, KNOTS	
DEPTH, FT	63	MAX.	2.9
DATE	MAR. 26-27, 1952	MEAN	1.48
REFERENCE FIG.	4-4	MIN.	0.4

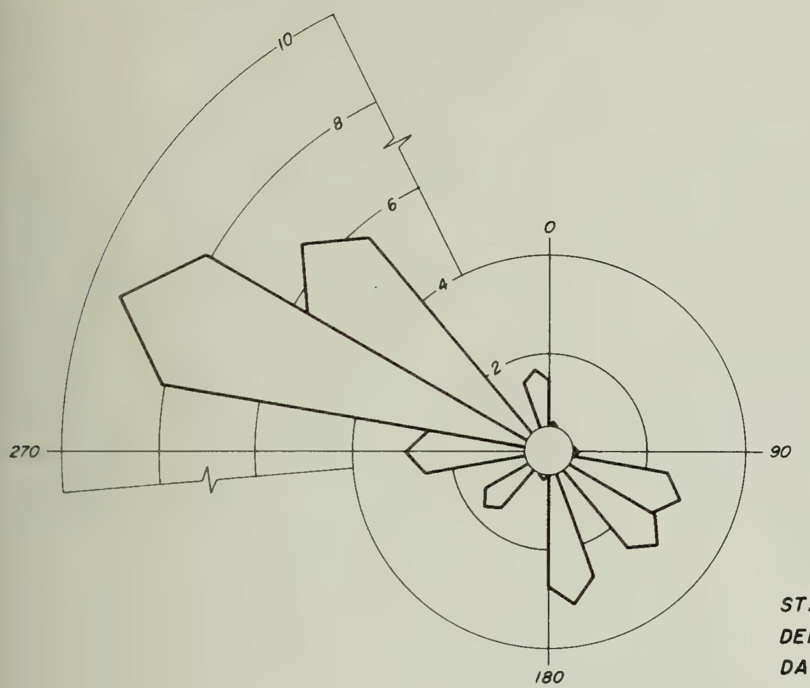
PERIOD OF OBSERVATION 0000 MAR. 26-0100 MAR. 27



STATION	23	CURRENT, KNOTS	
DEPTH, FT	63	MAX.	2.8
DATE	MAR. 28-29, 1952	MEAN	1.22
REFERENCE FIG.	4-4	MIN.	0.2

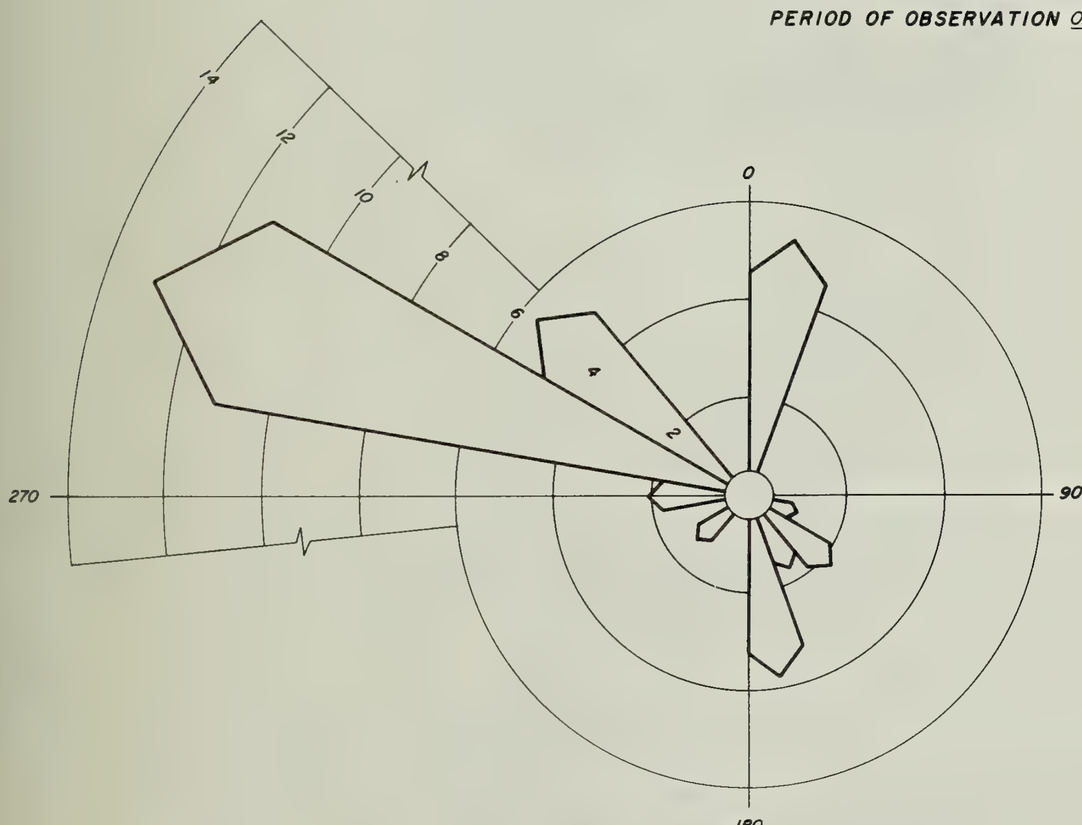
PERIOD OF OBSERVATION 0100 MAR. 28-0200 MAR. 29

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	33	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	3.0
DATE	FEB. 21-22, 1952	MEAN	1.33
REFERENCE FIG.	4-4	MIN.	0.2

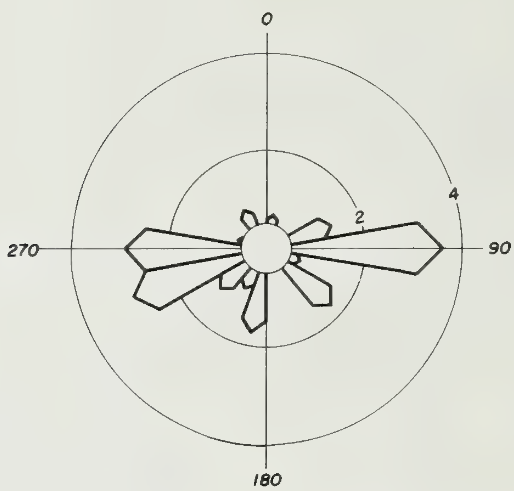
PERIOD OF OBSERVATION 0700 FEB. 21-0800 FEB. 22



STATION	33	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.8
DATE	FEB 23-24, 1952	MEAN	1.44
REFERENCE FIG.	4-4	MIN.	0.3

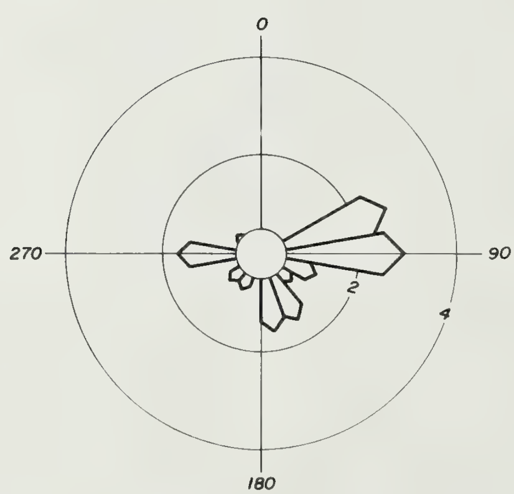
PERIOD OF OBSERVATION 1000 FEB. 23-1100 FEB 24

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 33
DEPTH, FT 71
DATE FEB. 21-22, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0700 FEB. 21-0800 FEB. 22

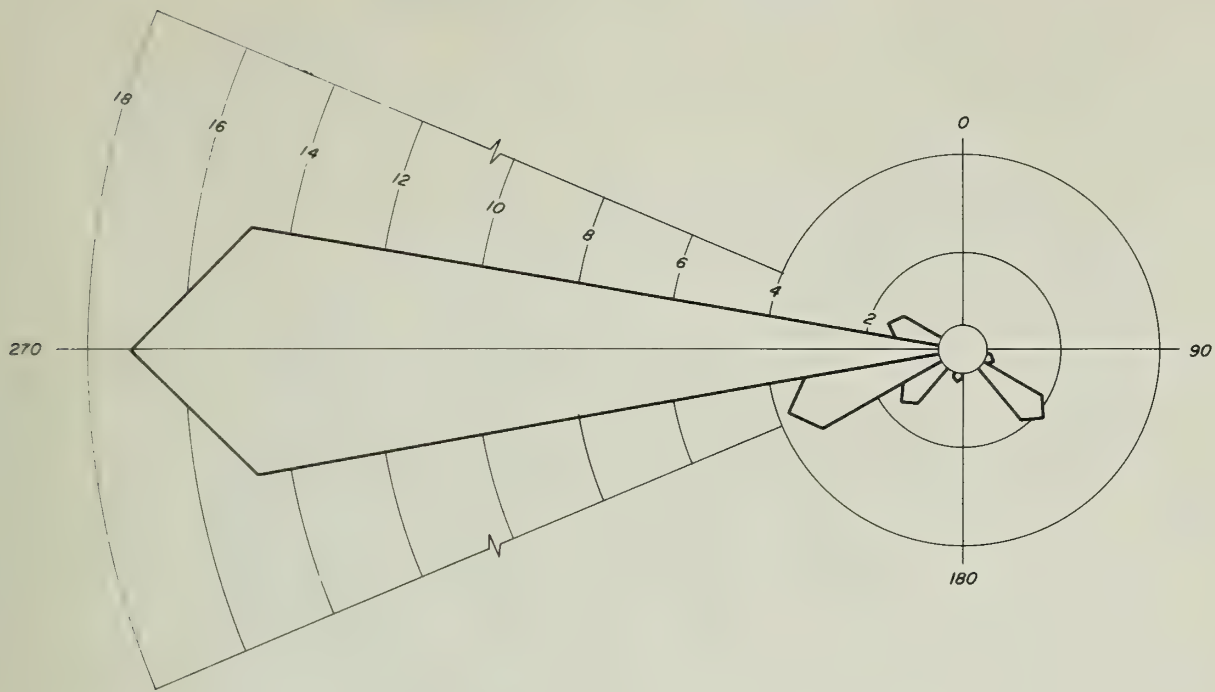
CURRENT, KNOTS
MAX. 2.0
MEAN 0.80
MIN. 0.2



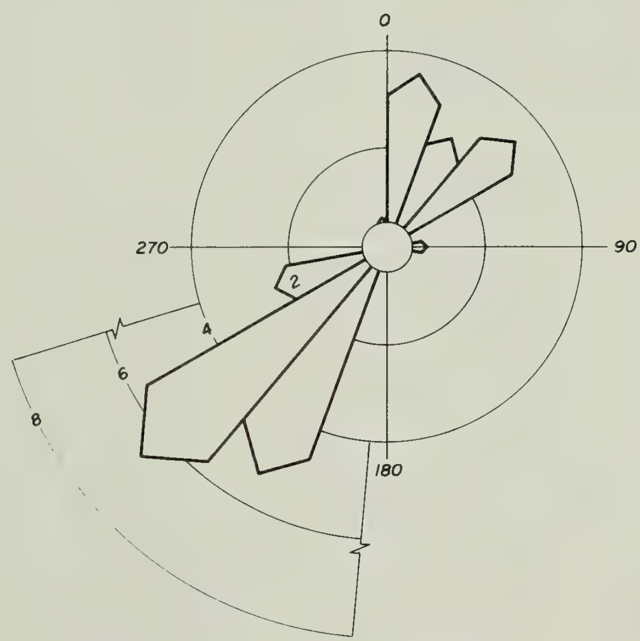
STATION 33
DEPTH, FT 71
DATE FEB. 23-24, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1000 FEB. 23-1100 FEB. 24

CURRENT, KNOTS
MAX. 1.9
MEAN 0.90
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)

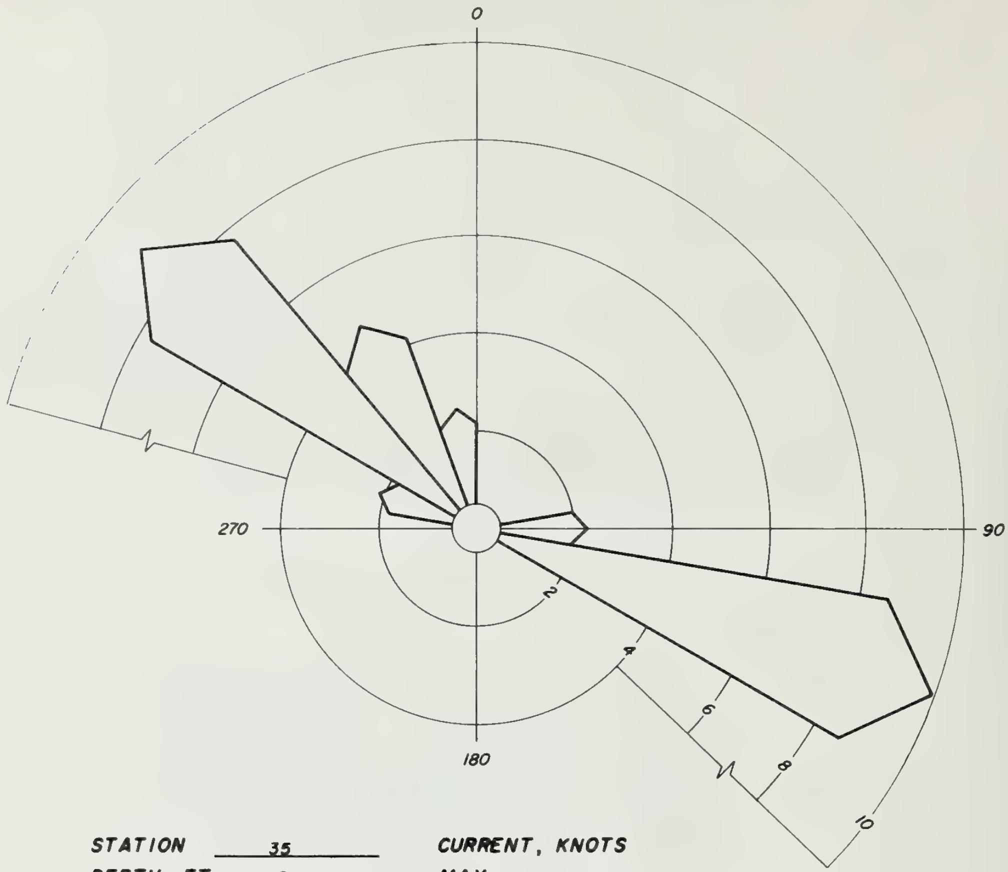


STATION	34	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	3.3
DATE	FEB. 23-24, 1952	MEAN	1.16
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	0900 FEB. 23-1000 FEB. 24		



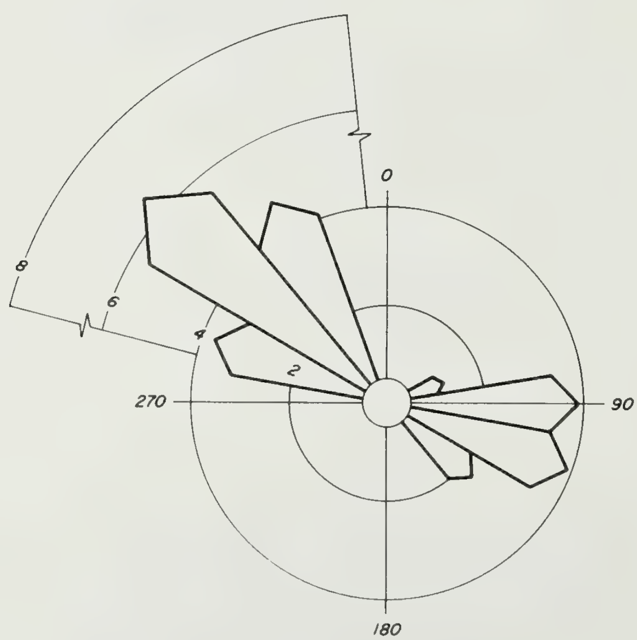
STATION	34	CURRENT, KNOTS	
DEPTH, FT	80	MAX.	2.2
DATE	FEB. 23-24, 1952	MEAN	1.03
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	0900 FEB. 23-1000 FEB. 24		

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 35
DEPTH, FT 8
DATE AUG. 25-26, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1400 AUG. 25-1500 AUG. 26

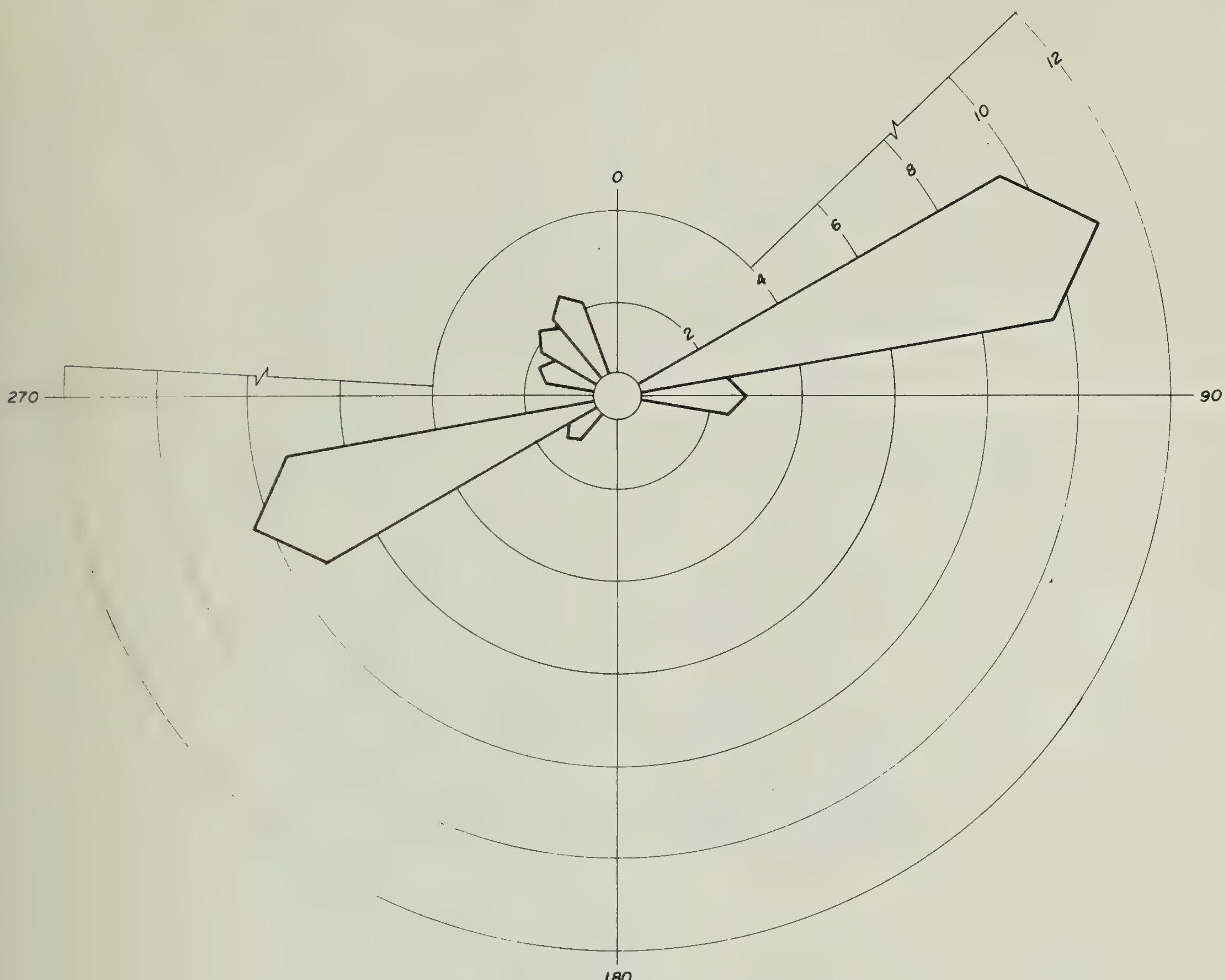
CURRENT, KNOTS
MAX. 2.5
MEAN 1.25
MIN. 0.2



STATION 35
DEPTH, FT 8
DATE AUG. 28-29, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1600 AUG. 28-1700 AUG. 29

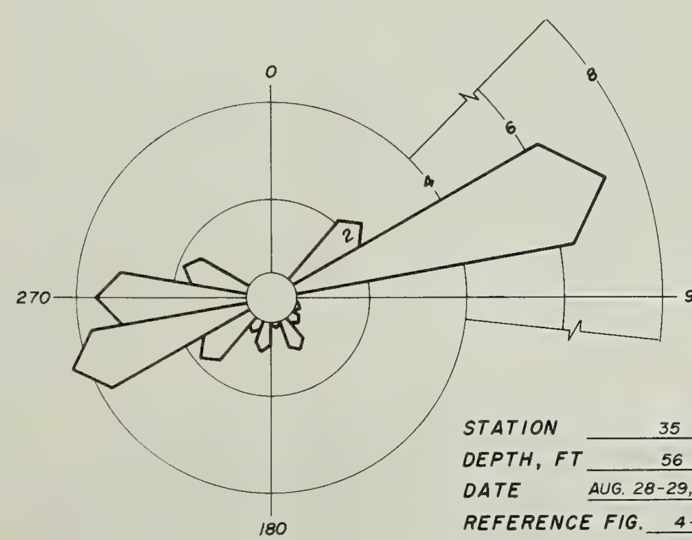
CURRENT, KNOTS
MAX. 2.6
MEAN 1.06
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 35
DEPTH, FT 56
DATE AUG. 25-26, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1400 AUG. 25-1500 AUG. 26

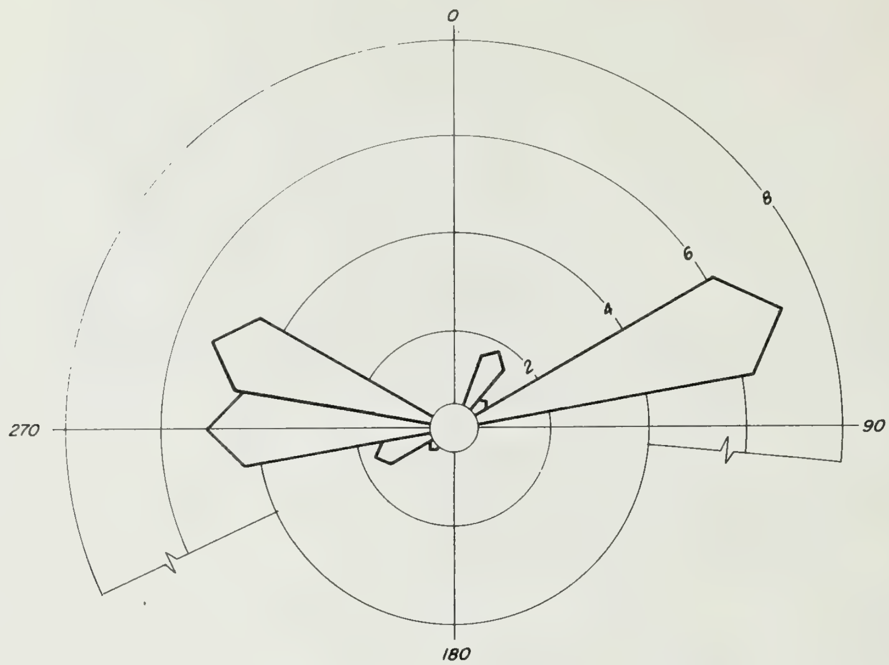
CURRENT, KNOTS
MAX. 2.7
MEAN 1.25
MIN. 0.2



STATION 35
DEPTH, FT 56
DATE AUG. 28-29, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1600 AUG. 28 - 1700 AUG. 29

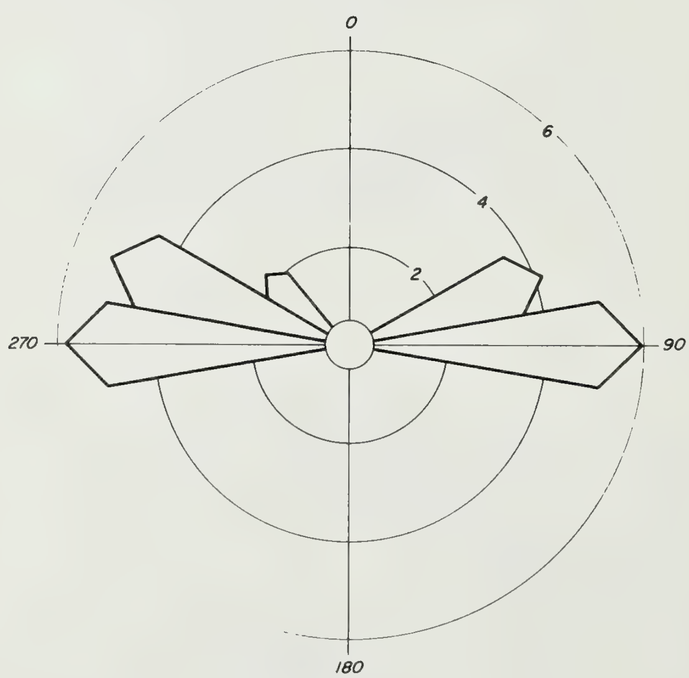
CURRENT, KNOTS
MAX. 2.2
MEAN 1.07
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 36
DEPTH, FT 8
DATE SEPT. 1-2, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1900 SEPT. 1-2000 SEPT. 2

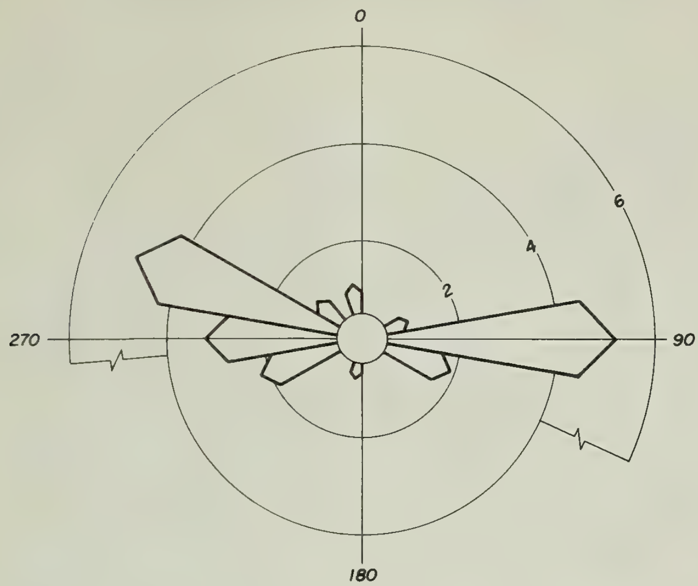
CURRENT, KNOTS
MAX. 1.8
MEAN 0.91
MIN. 0.2



STATION 36
DEPTH, FT 8
DATE SEPT. 4-5, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 2200 SEPT. 4-2300 SEPT. 5

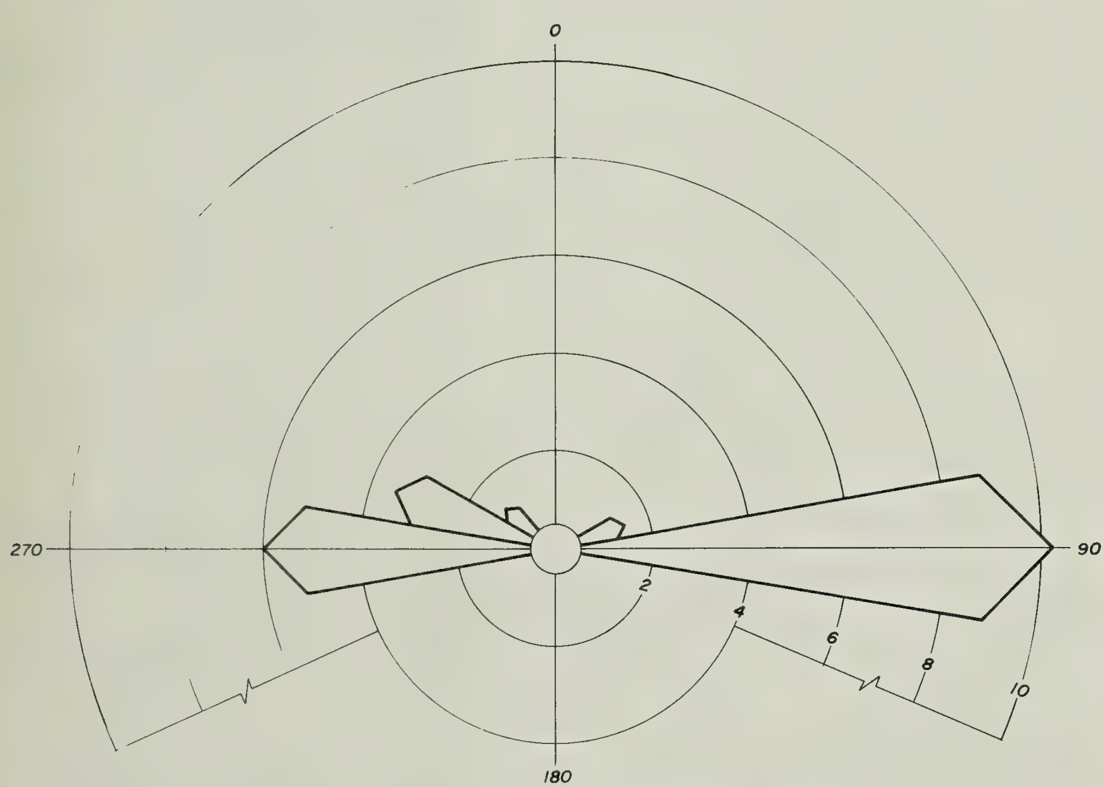
CURRENT, KNOTS
MAX. 2.0
MEAN 0.98
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 36
DEPTH, FT 21
DATE SEPT. 1-2, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 1900 SEPT. 1-2000 SEPT. 2

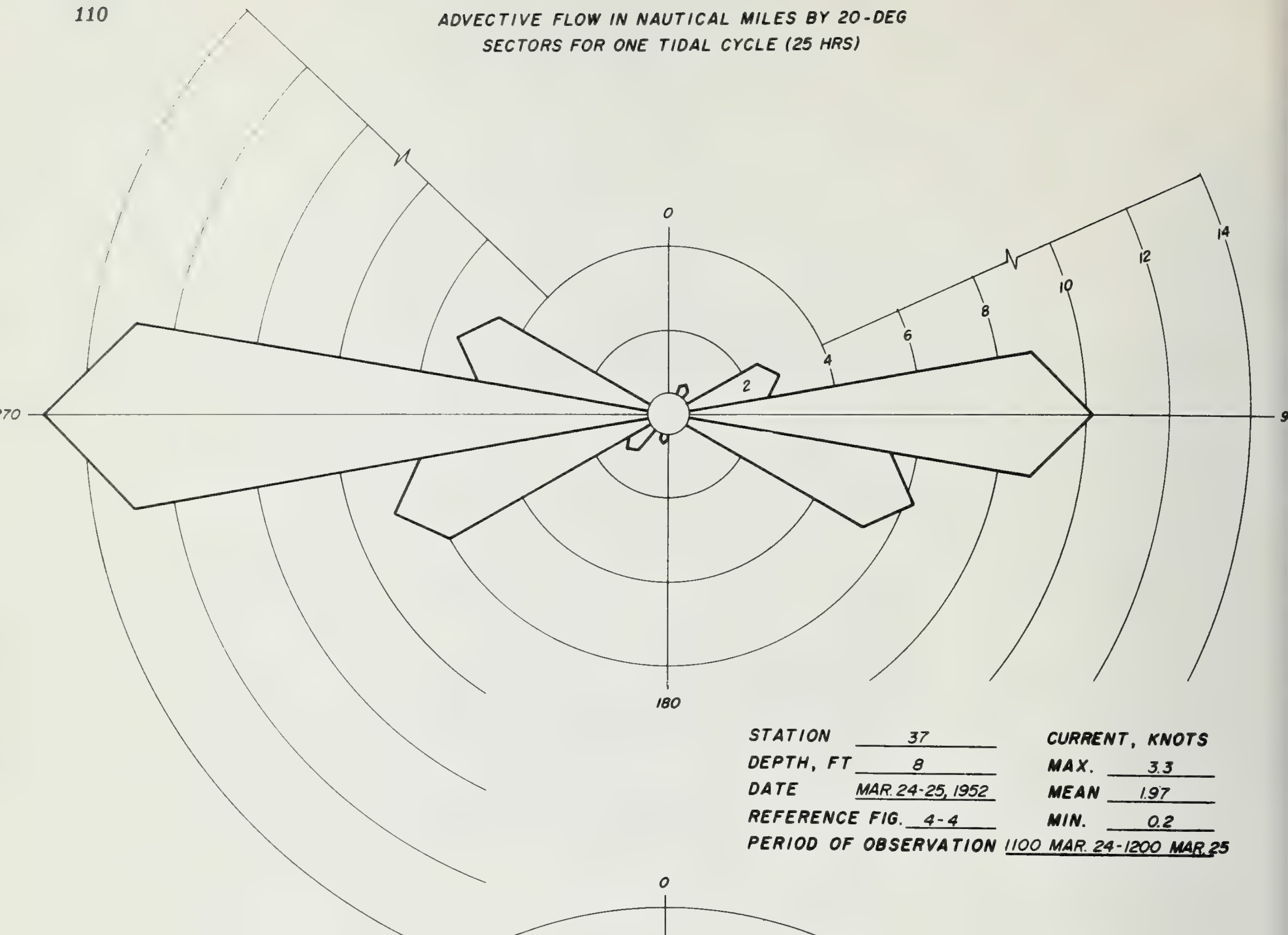
CURRENT, KNOTS
MAX. 1.7
MEAN 0.86
MIN. 0.2



STATION 36
DEPTH, FT 21
DATE SEPT. 4-5, 1953
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 2200 SEPT. 4-2300 SEPT. 5

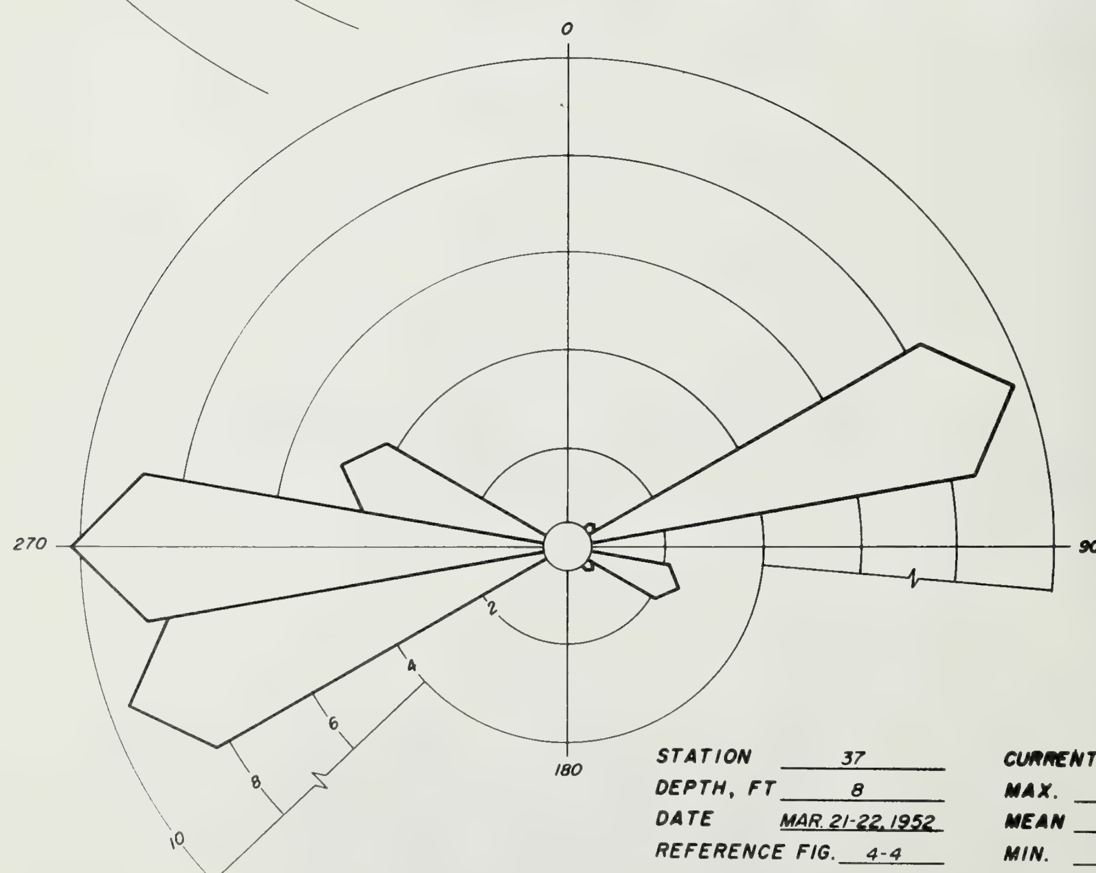
CURRENT, KNOTS
MAX. 1.9
MEAN 0.95
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	37	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	3.3
DATE	MAR. 24-25, 1952	MEAN	1.97
REFERENCE FIG.	4-4	MIN.	0.2

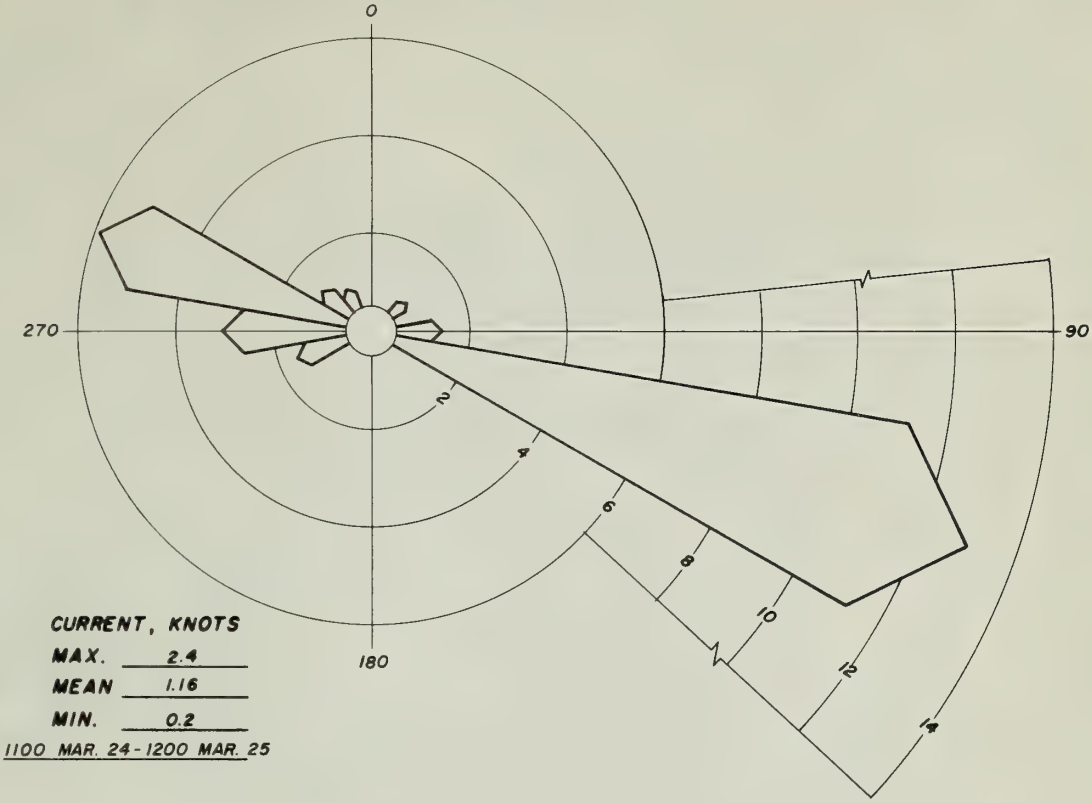
PERIOD OF OBSERVATION 1100 MAR. 24-1200 MAR. 25



STATION	37	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	3.4
DATE	MAR. 21-22, 1952	MEAN	1.56
REFERENCE FIG.	4-4	MIN.	0.4

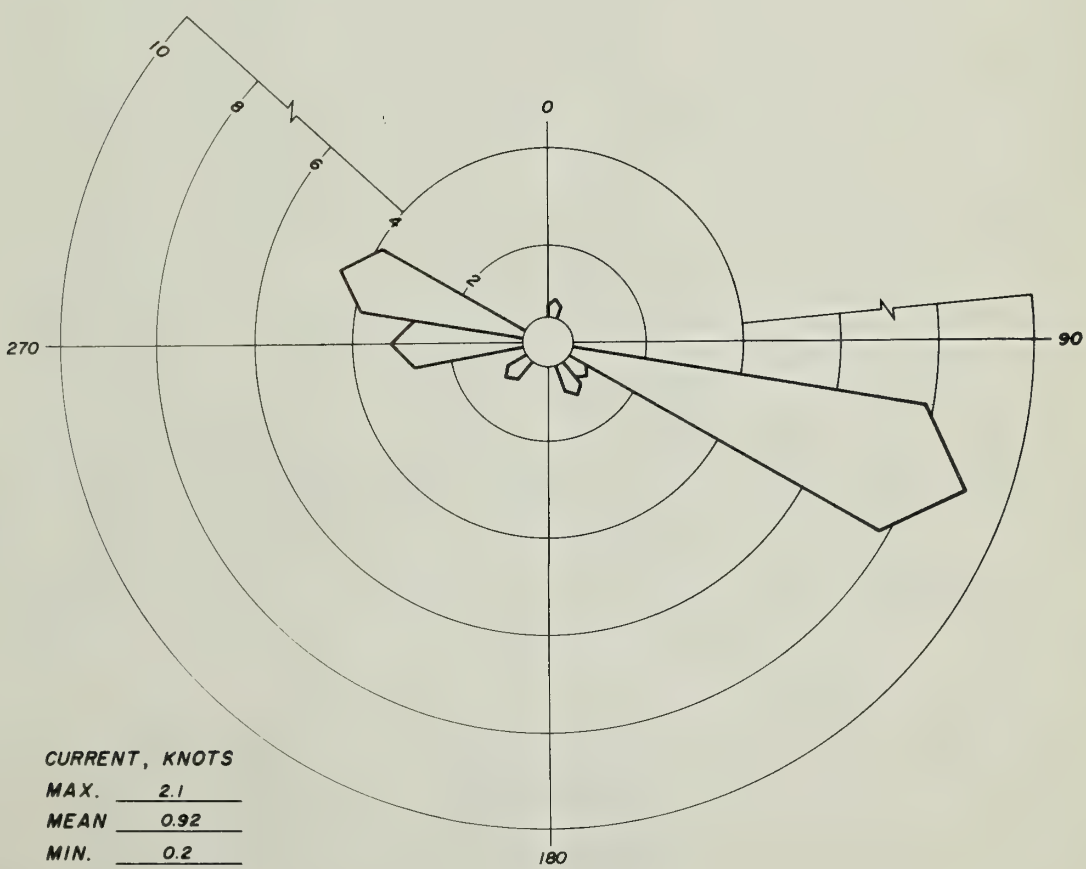
PERIOD OF OBSERVATION 2200 MAR. 21-2300 MAR. 22

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	37	CURRENT, KNOTS	
DEPTH, FT	48	MAX.	2.4
DATE	MAR. 24-25, 1952	MEAN	1.16
REFERENCE FIG.	4-4	MIN.	0.2

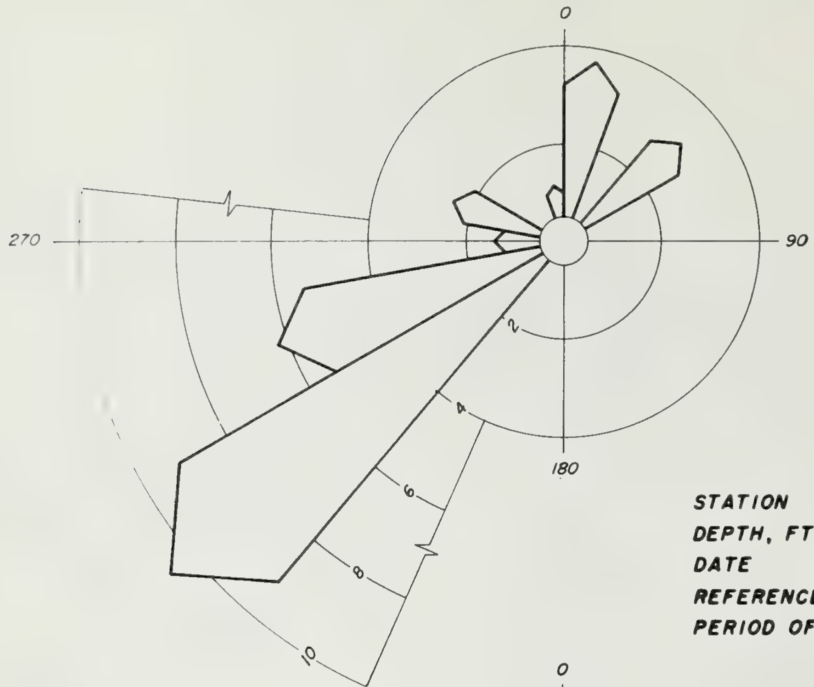
PERIOD OF OBSERVATION 1100 MAR. 24-1200 MAR. 25



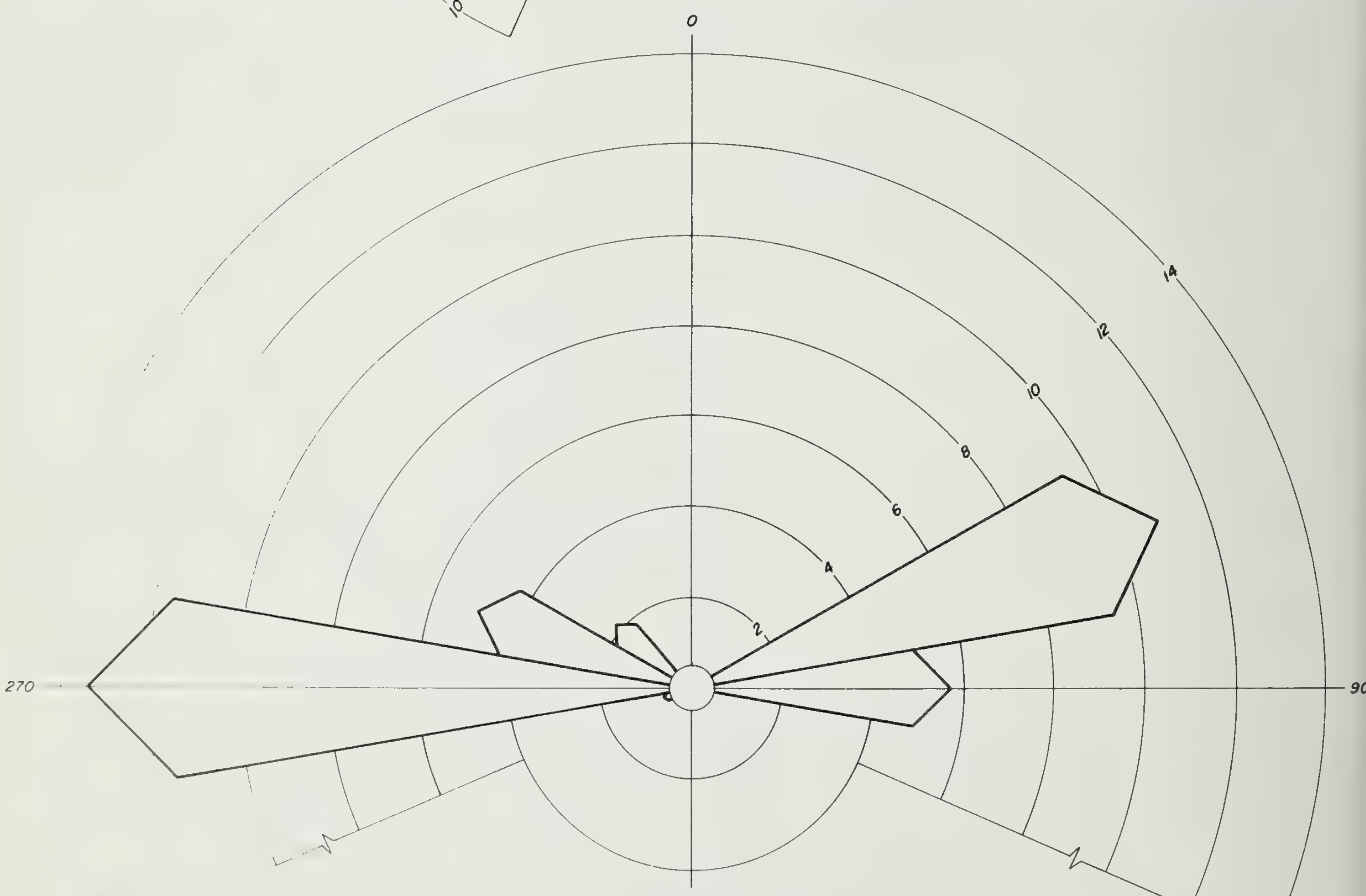
STATION	37	CURRENT, KNOTS	
DEPTH, FT	48	MAX.	2.1
DATE	MAR. 21-22, 1952	MEAN	0.92
REFERENCE FIG.	4-4	MIN.	0.2

PERIOD OF OBSERVATION 2200 MAR. 21-2300 MAR. 22

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)

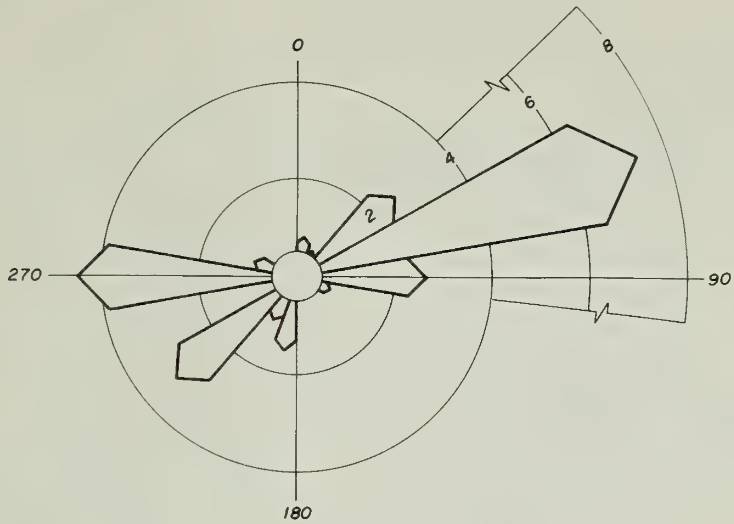


STATION	38	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.6
DATE	MAR. 6-7, 1952	MEAN	1.17
REFERENCE FIG.	4-4	MIN.	0.2
PERIOD OF OBSERVATION	0900 MAR. 6-1000 MAR. 7		



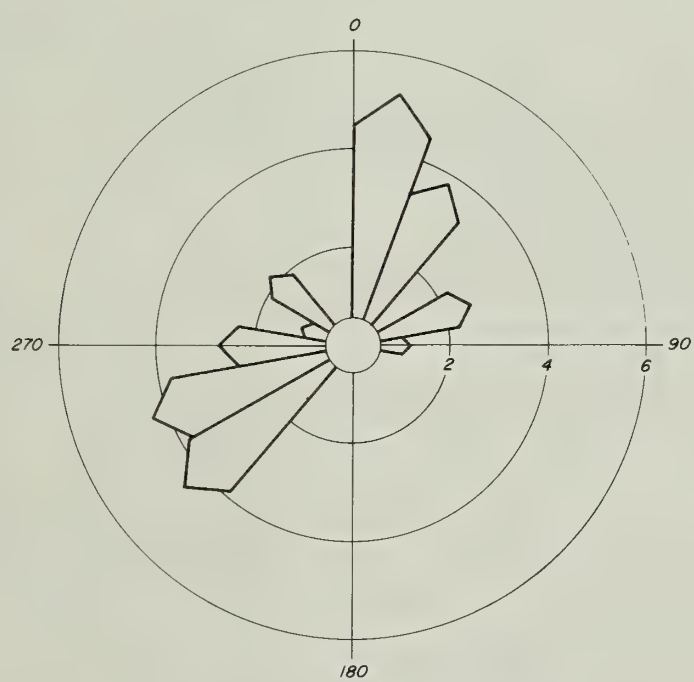
STATION	38	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.9
DATE	MAR. 14-15, 1952	MEAN	1.53
REFERENCE FIG.	4-4	MIN.	0.5
PERIOD OF OBSERVATION	0200 MAR. 14-0300 MAR. 15		

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION 38
DEPTH, FT 48
DATE MAR. 6-7, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0900 MAR. 6-1000 MAR. 7

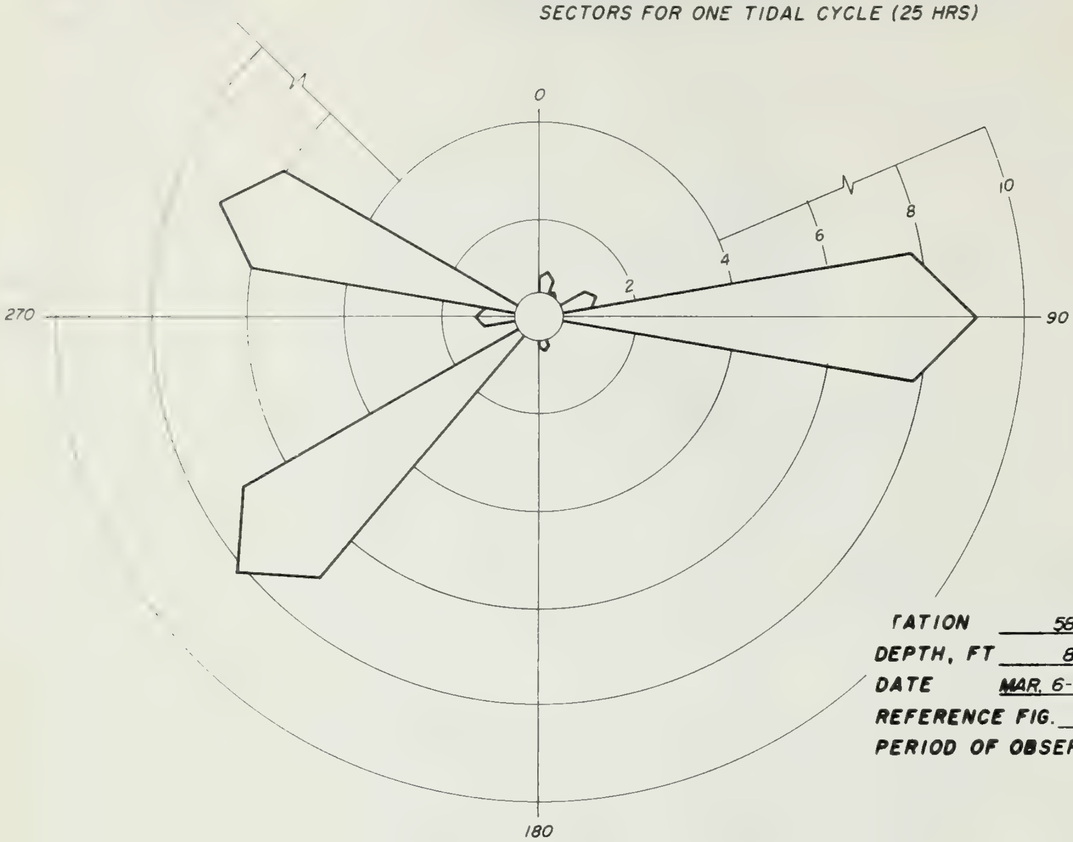
CURRENT, KNOTS
MAX. 1.9
MEAN 1.04
MIN. 0.3



STATION 57
DEPTH, FT 8
DATE MAR. 6-7, 1952
REFERENCE FIG. 4-4
PERIOD OF OBSERVATION 0800 MAR. 6-0900 MAR. 7

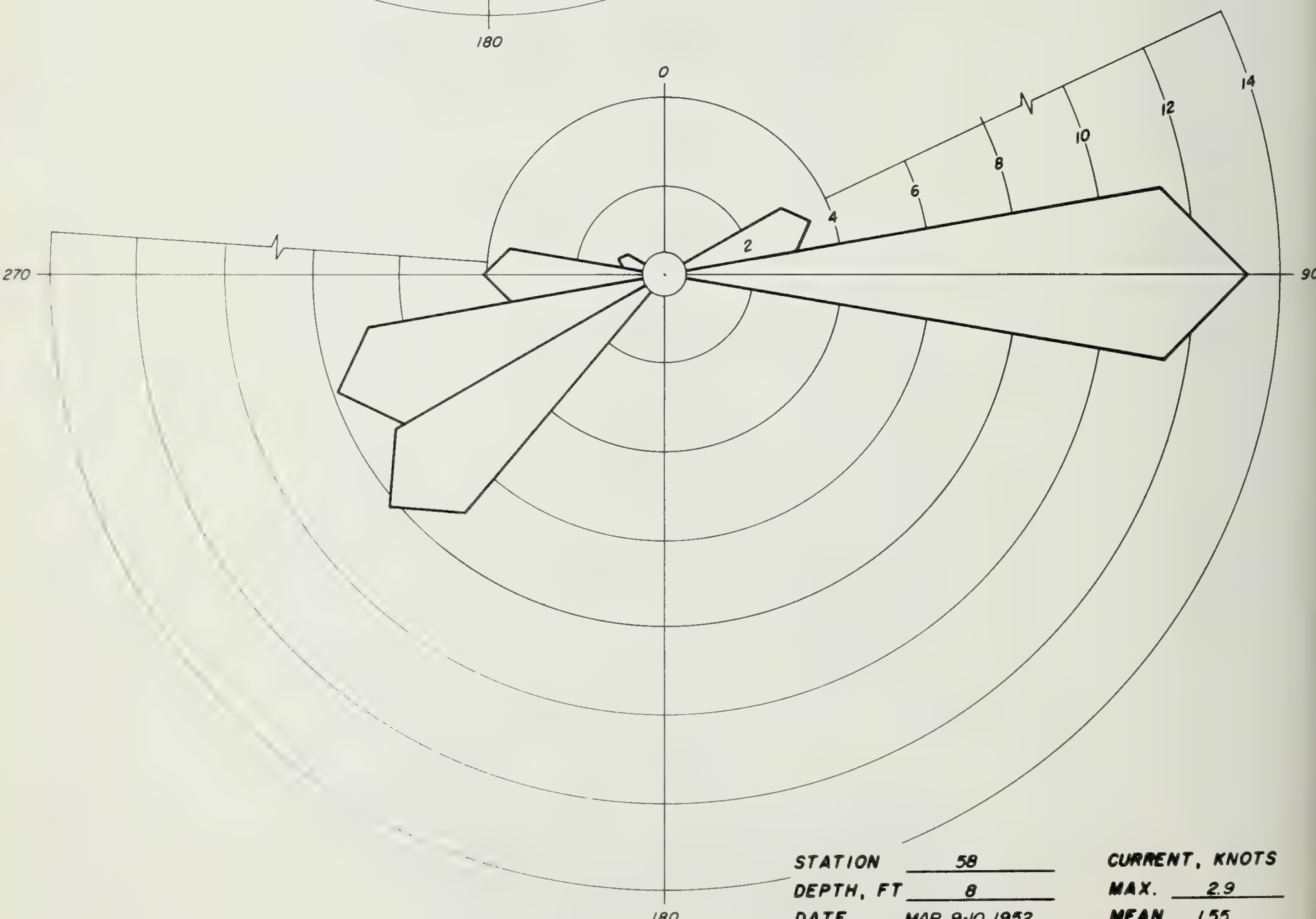
CURRENT, KNOTS
MAX. 2.8
MEAN 1.13
MIN. 0.2

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG
SECTORS FOR ONE TIDAL CYCLE (25 HRS)



TATION	58	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.9
DATE	MAR. 6-7, 1952	MEAN	1.94
REFERENCE FIG.	4-4	MIN.	0.3

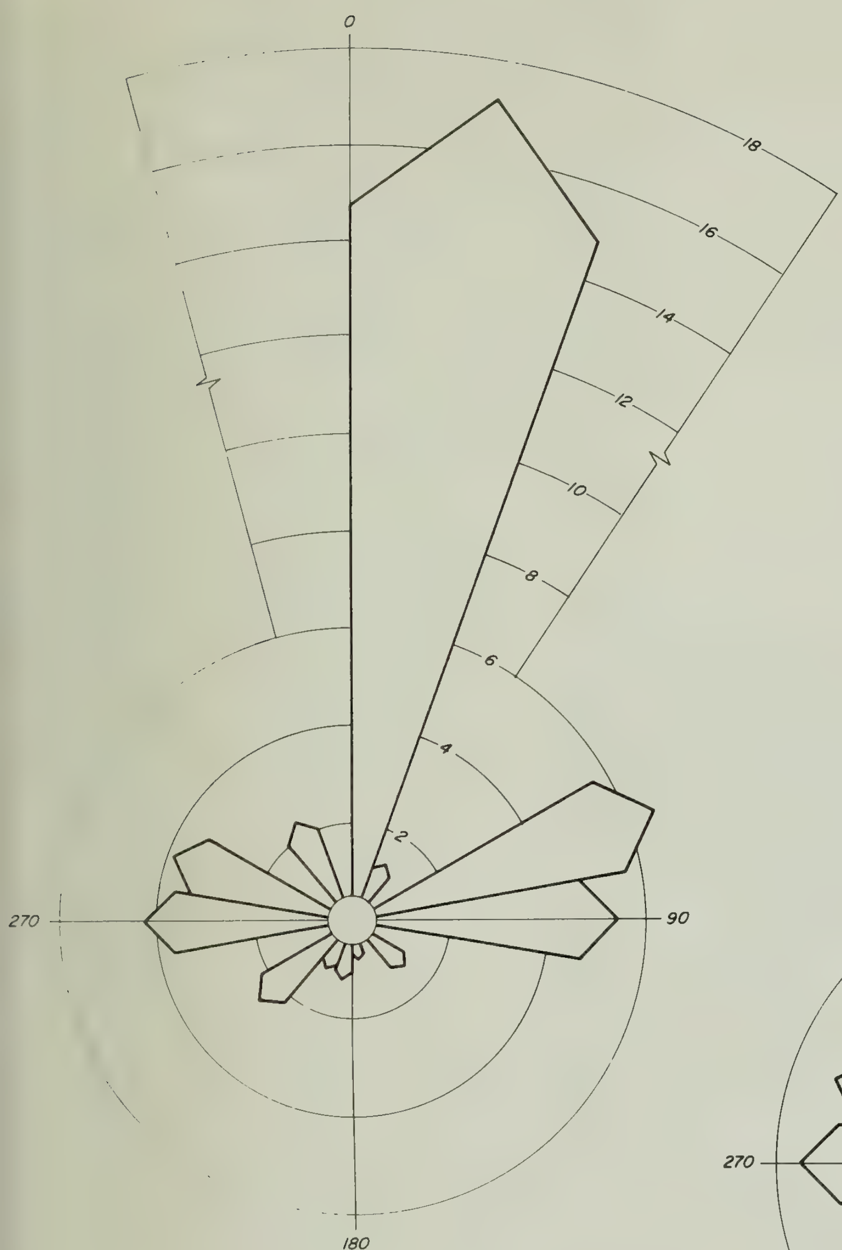
PERIOD OF OBSERVATION 0900 MAR. 6-1000 MAR. 7



STATION	58	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	2.9
DATE	MAR. 9-10, 1952	MEAN	1.55
REFERENCE FIG.	4-4	MIN.	0.4

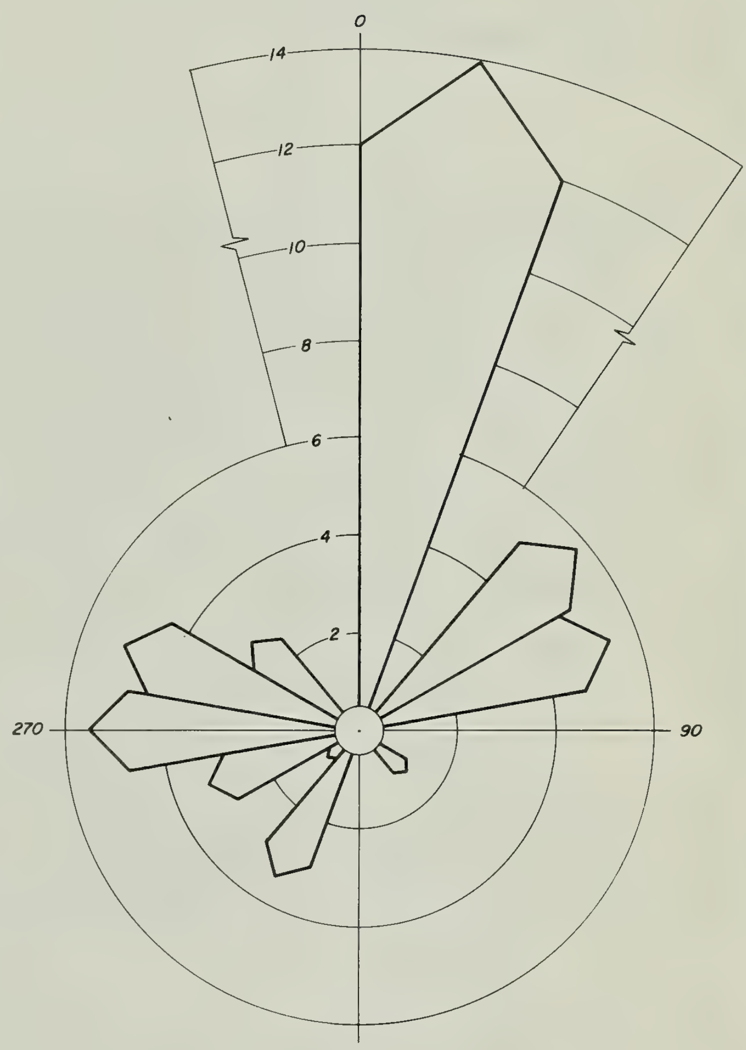
PERIOD OF OBSERVATION 1100 MAR. 9-1200 MAR. 10

ADVECTIVE FLOW IN NAUTICAL MILES BY 20-DEG SECTORS FOR ONE TIDAL CYCLE (25 HRS)



STATION	59	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	4.0
DATE	MAR. 27-28, 1952	MEAN	1.93
REFERENCE FIG.	4-4	MIN.	0.3

PERIOD OF OBSERVATION 0100 MAR. 27-0200 MAR. 28



STATION	59	CURRENT, KNOTS	
DEPTH, FT	8	MAX.	3.9
DATE	MAR. 25-26, 1952	MEAN	1.91
REFERENCE FIG.	4-4	MIN.	0.2

PERIOD OF OBSERVATION 0000 MAR. 25-0100 MAR. 26

Reference Figures

Fig. 4-4 **Current Meter Stations, USC&GS Survey, 1952, 1953, and 1954**

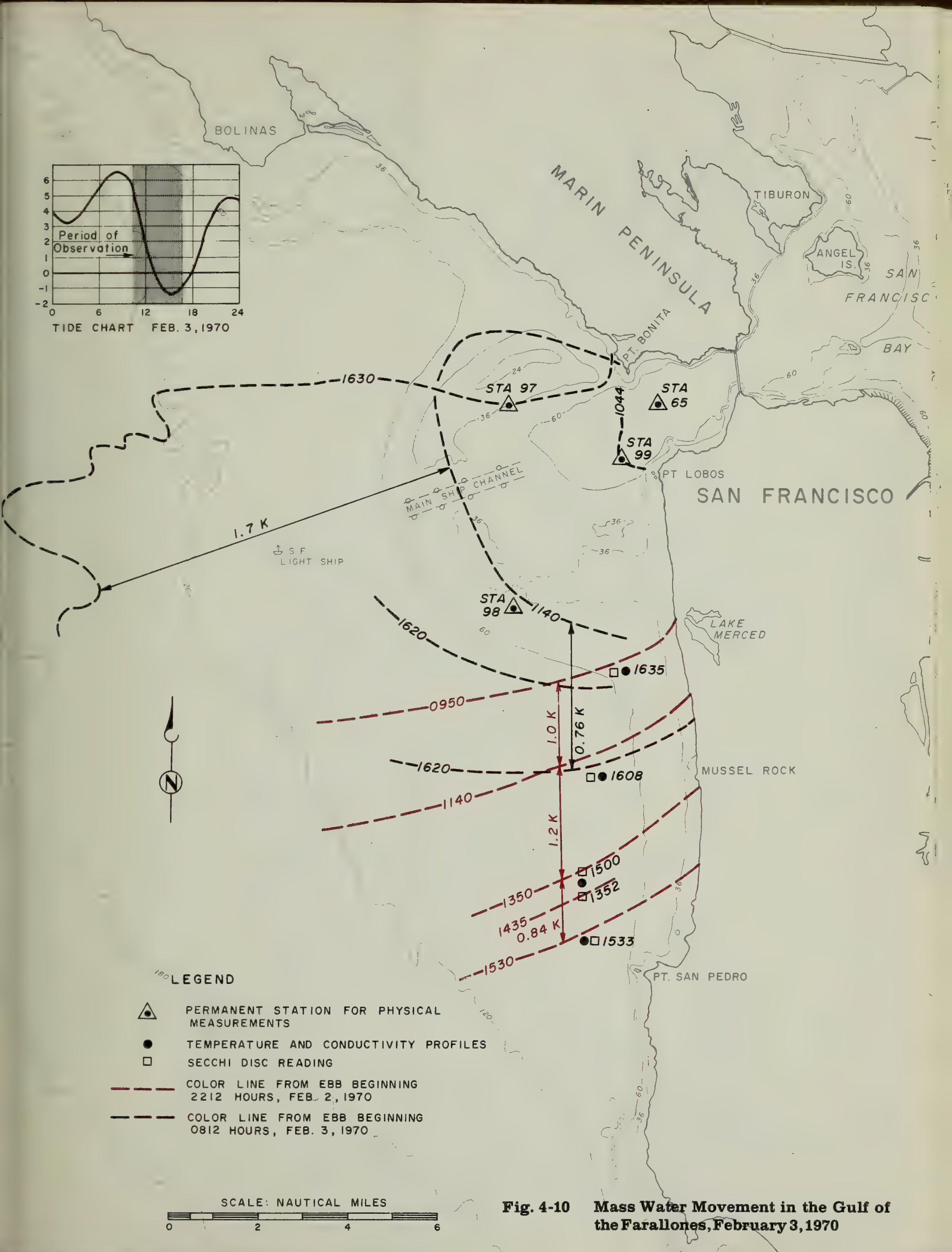


Fig. 4-10 **Mass Water Movement in the Gulf of the Farallones, February 3, 1970**

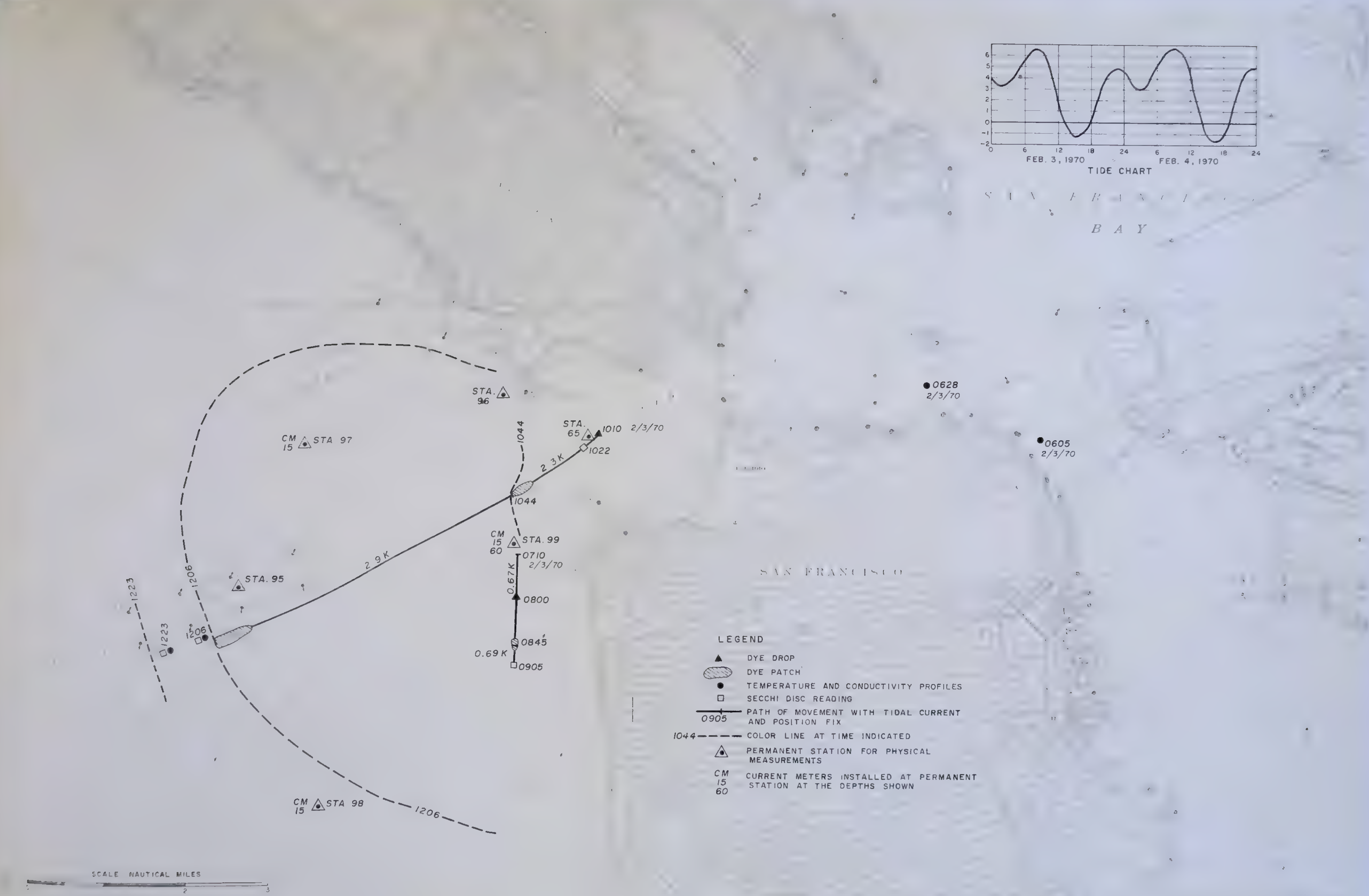


Fig. 4-12 Physical Oceanography in the Gulf of the Farallones, February 3-4, 1970

Fig. 4-13 Physical Oceanography in the Gulf of the Farallones, February 24-25, 1970

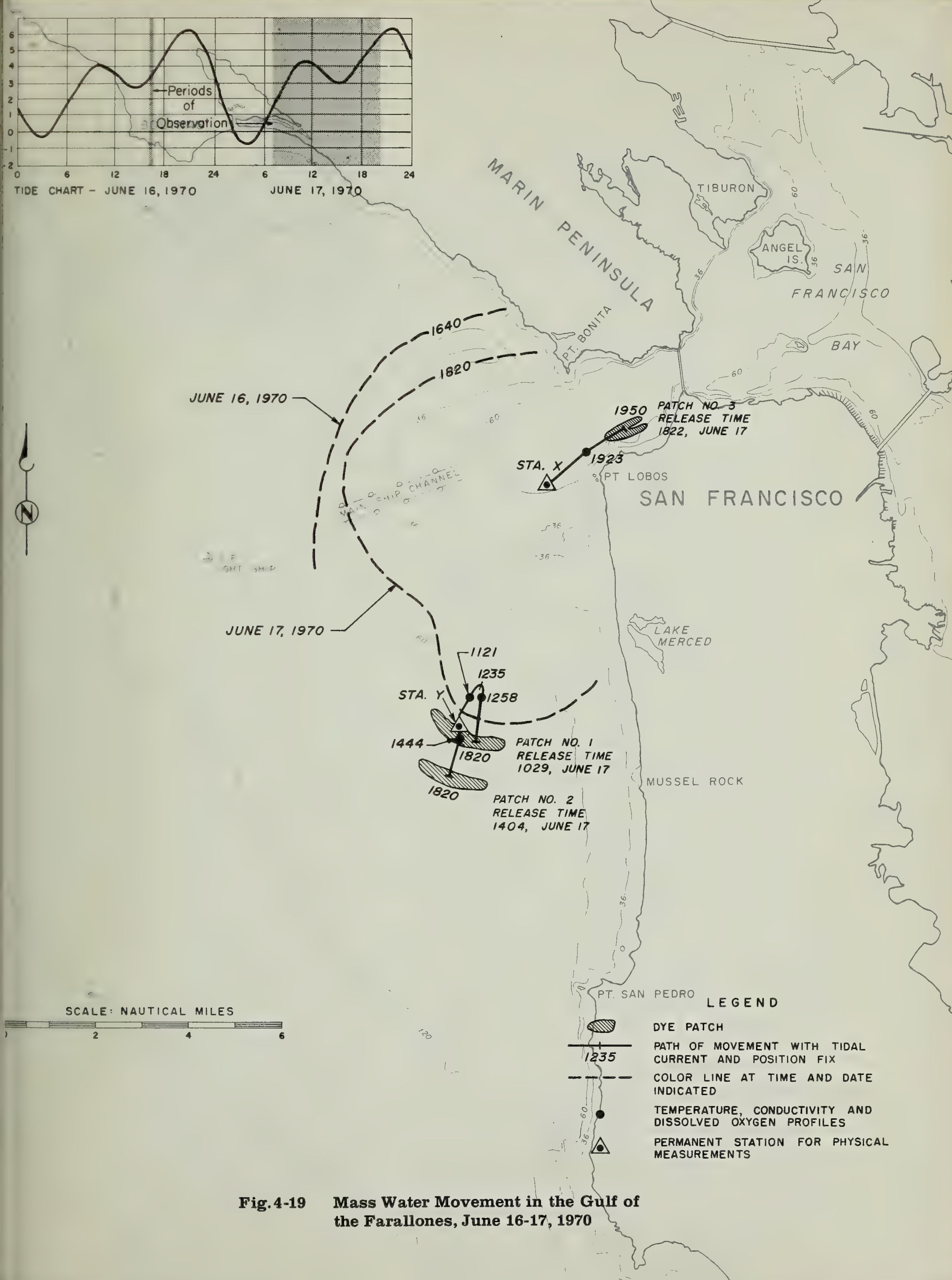


Fig.4-19 Mass Water Movement in the Gulf of the Farallones, June 16-17, 1970

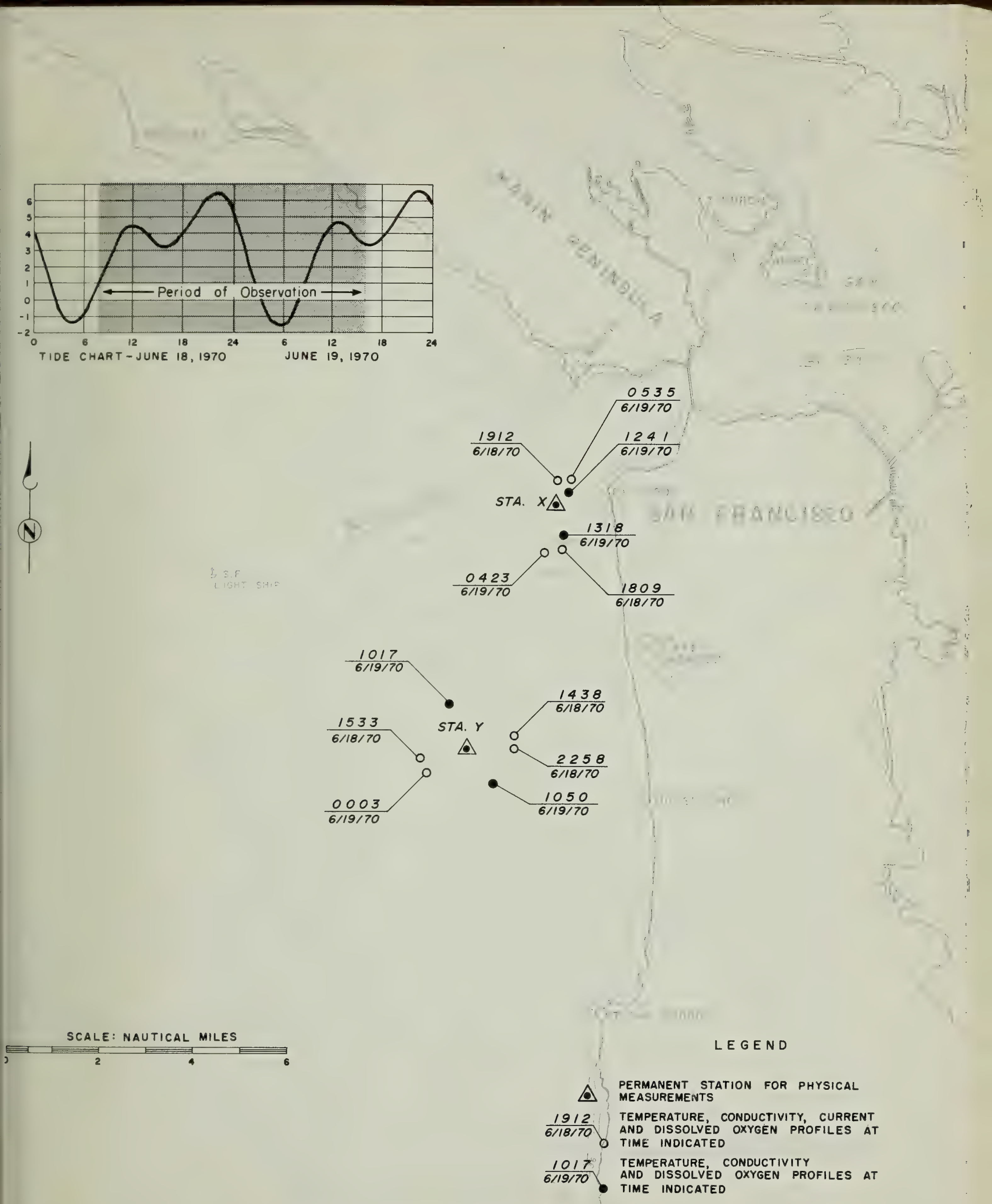


Fig. 4-20 Physical Oceanography in the Gulf of the Farallones, June, 1970

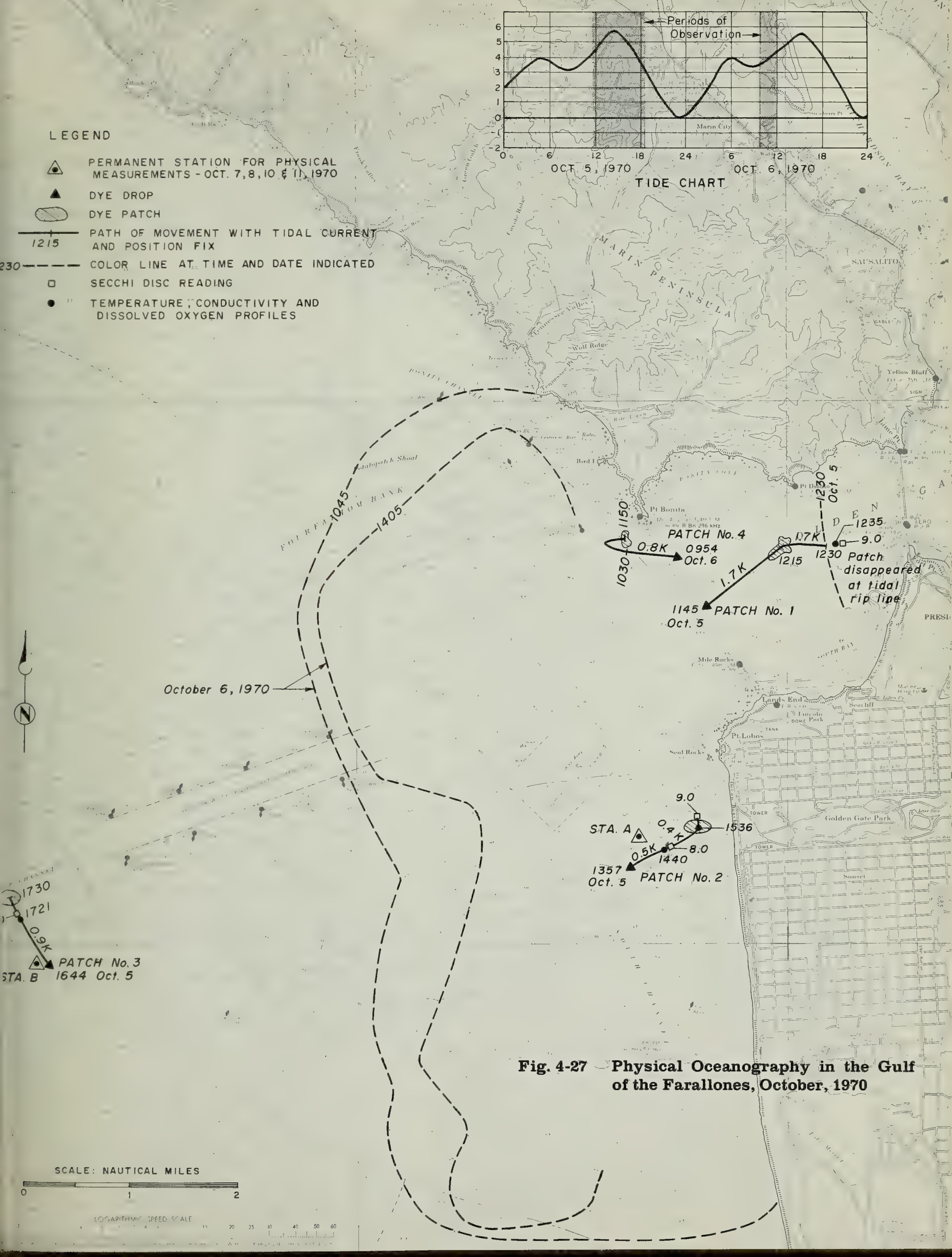


Fig. 4-27 Physical Oceanography in the Gulf of the Farallones, October, 1970

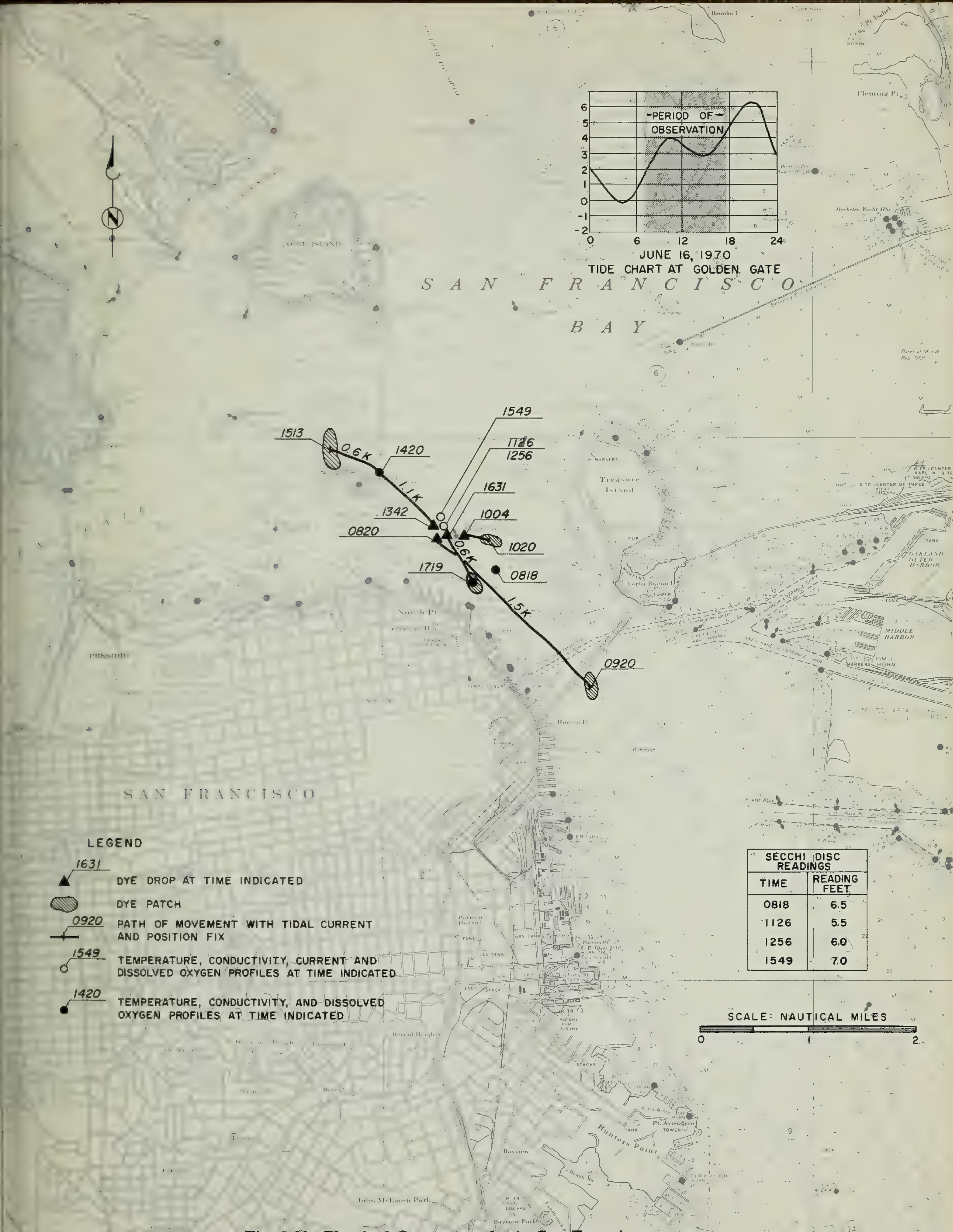


Fig. 4-39 Physical Oceanography in San Francisco Bay, June 16, 1970

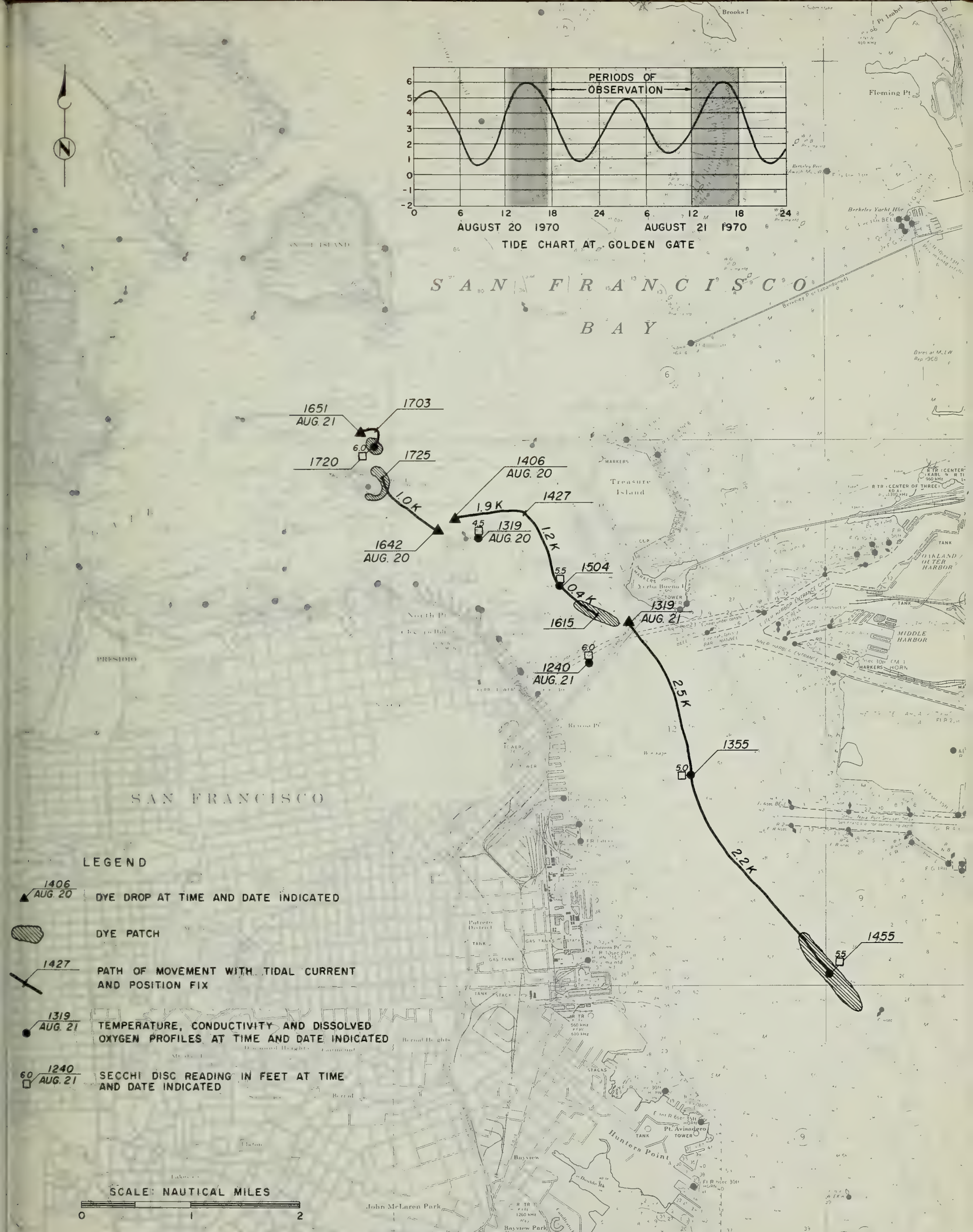


Fig. 4-40 Physical Oceanography in San Francisco Bay, August 20-21, 1970

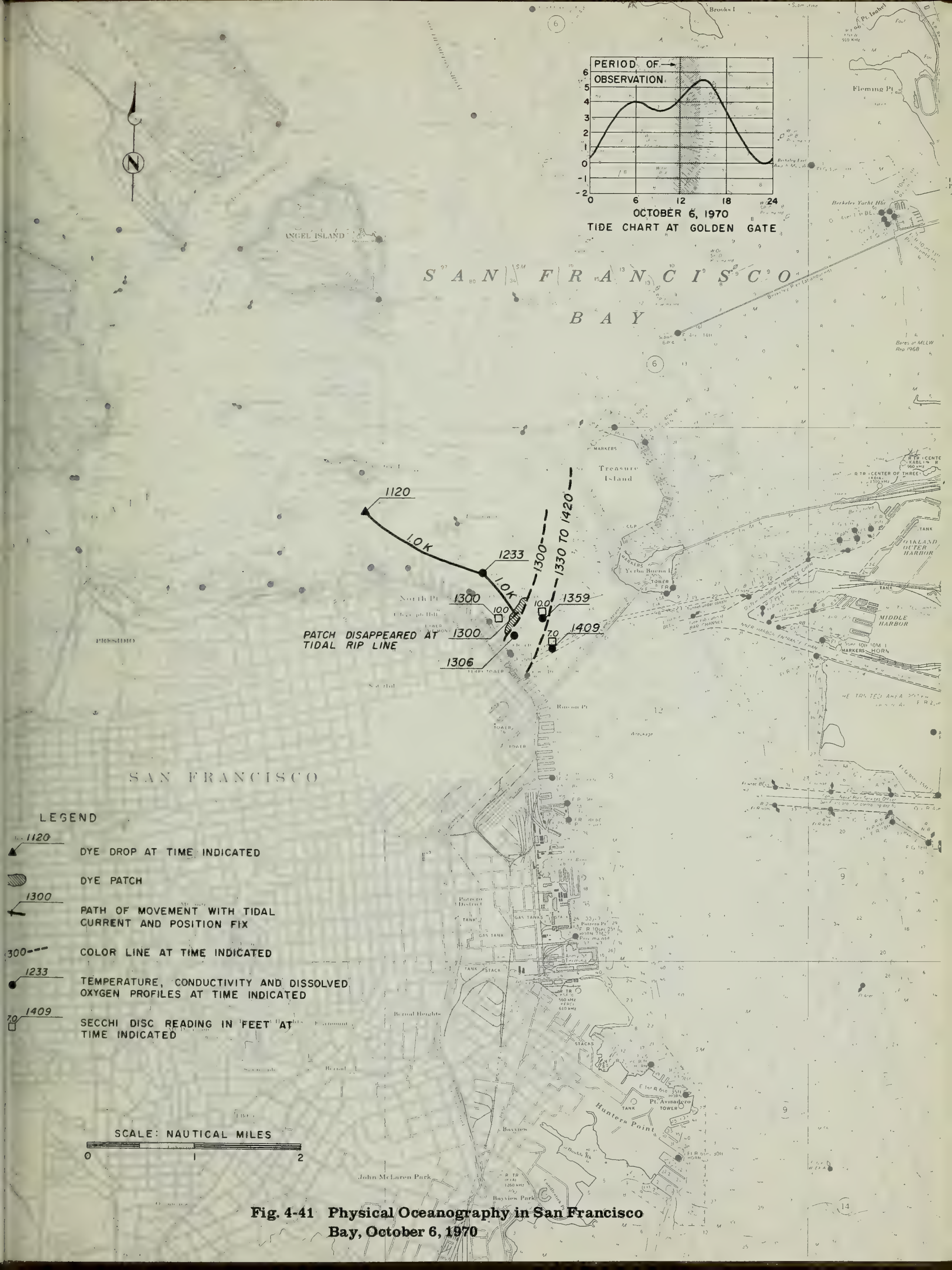


Fig. 4-41 Physical Oceanography in San Francisco Bay, October 6, 1970

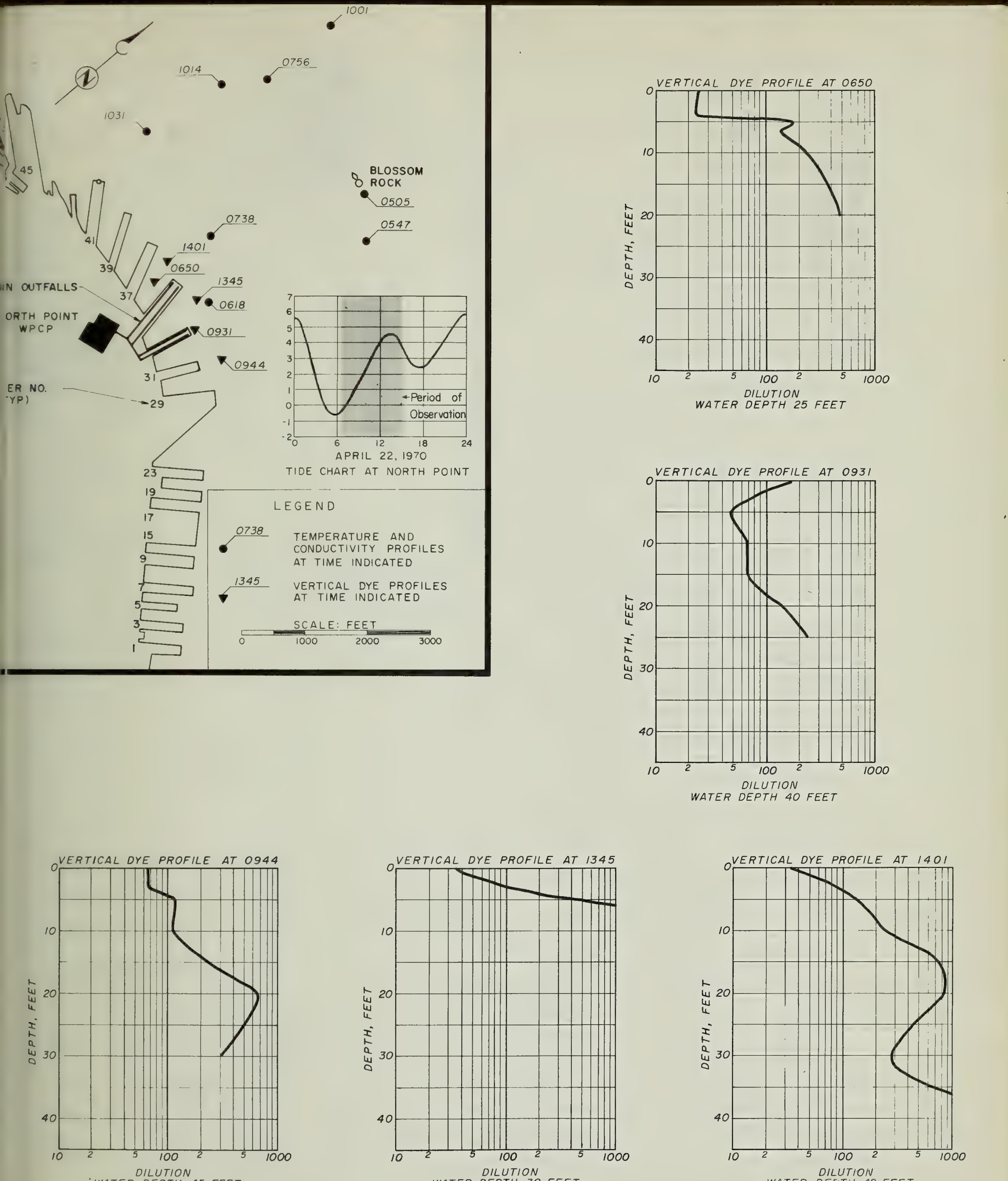


Fig. 4-45 Measured Vertical Effluent Dispersion at North Point Outfall April 22, 1970

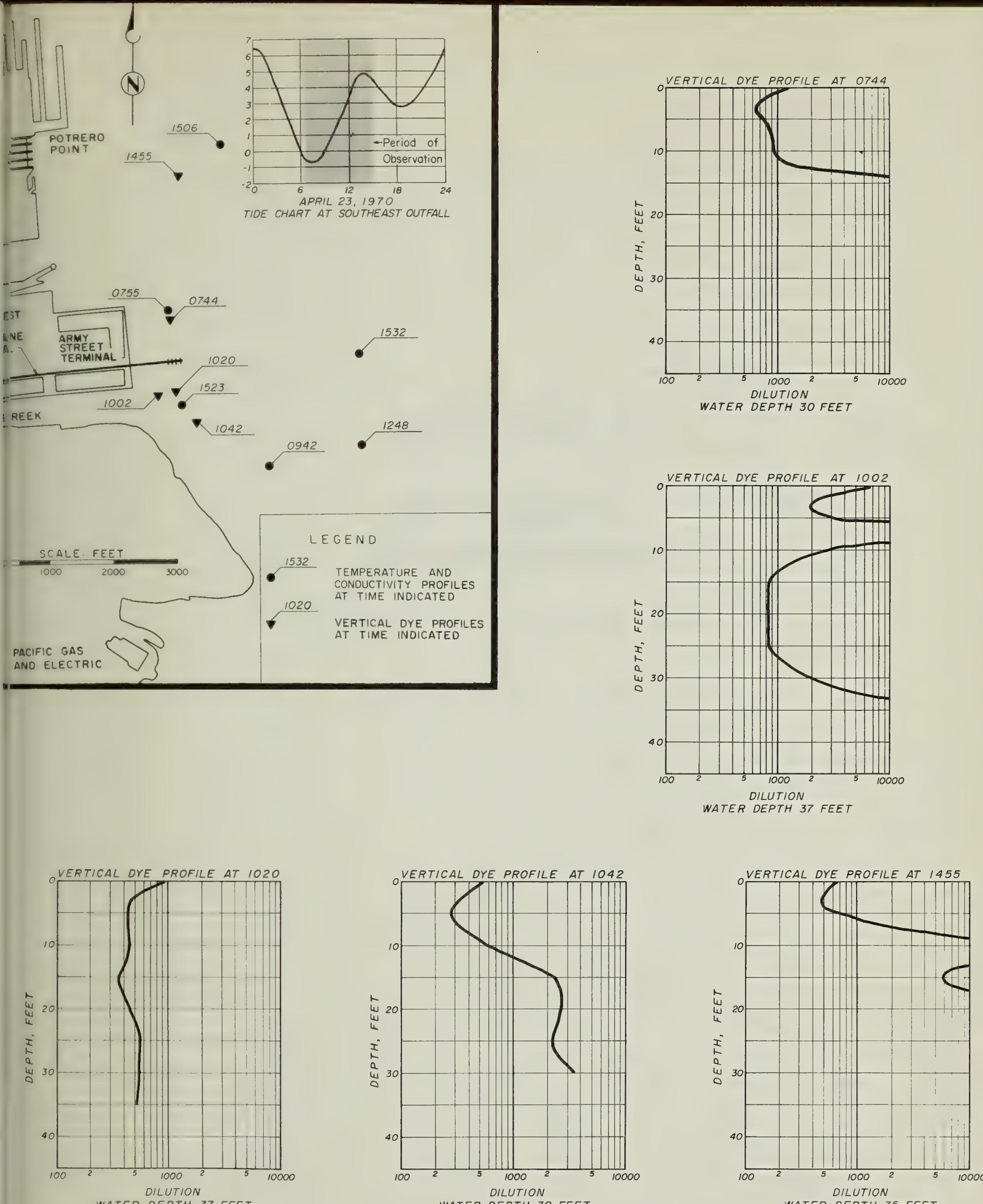


Fig. 4-47 Measured Vertical Effluent Dispersion at Southeast Outfall April 23, 1970

SECTION II

Ecological Investigations

FIELD DATA

Plankton Studies

Reference: Fig. 5-17

PLANKTON ANALYSIS

STATION FG-6 DATE December 1969 COLLECTED BY Fish & Game LAB NO. 01

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.3 CONCENTRATED VOLUME (ml) 175 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS COPEPODS

NUMBER OF ORGANISMS/M^3 471.7 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.62

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPOD	36	287.7		
CYCLOPOID COPEPOD	3	18.5		
AMPHIPOD	2	12.3		
BARNACLE NAUPLII	1	6.2		
BARNACLE LARVAEE	1	6.2		
BRACHYURAN LARVAE	2	23.8		
SNAIL LARVAE	8	49.2		
VELIGER LARVAE	3	18.5		
FRITILLARIA	3	18.5		
LARVACEANS (OIKOPLEURA)	3	18.5		
FISH EGG	2	12.3		
	64	471.7		

PLANKTON ANALYSIS

STATION FG-7 DATE December 1969 COLLECTED BY Fish & Game LAB NO. 02

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.2 CONCENTRATED VOLUME (ml) 75 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS SALPA

NUMBER OF ORGANISMS/M^3 13,760 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.05

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPOD	33	660		
CYCLOPOID COPEPOD	1	20		
EUPHAUSID SHRIMP	1	20		
CHAETOGNATHS	2	40		
SNAIL	6	120		
VELIGER LARVAE	1	20		
LARVACEANS (OIKOPLEURA)	3	60		
SALPA	638	12,760		
FISH POST LARVAE	1	20		
FISH EGGS	1	20		
BRACHYURAN LARVAE		20		
	687	13,760		

PLANKTON ANALYSIS

STATION FG-8 DATE December 1969 COLLECTED BY Fish & Game LAB NO. 03

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.6 CONCENTRATED VOLUME (ml) ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS SALPA

NUMBER OF ORGANISMS/M^3 5,829.8 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.04

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CYCLOPOID COPEPOD	1	13.3		
AMPHIPOD	3	40		
CHAETOGNATHS	4	53.3		
VELIGER LARVAE	1	13.3		
SALPA	385	5,133.3		
DOLIOLUM	5	66.7		
FISH LARVAE	1	13.3		
FISH EGGS	4	53.3		
BRACHYURAN LARVAE		3.3		
	437	5,829.8		

PLANKTON ANALYSIS

STATION FG-11 DATE December 1969 COLLECTED BY Fish & Game LAB NO. 04

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.6 CONCENTRATED VOLUME (ml) 50 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS SALPA

NUMBER OF ORGANISMS/M^3 2,768.3 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.14

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPOD	20	133.3		
CYCLOPOID COPEPOD	2	13.3		
BARNACLE NAUPLII	1	6.7		
CHAETOGNATHS	2	13.3		
SEA URCHIN LARVAE	1	6.7		
LARVACEANS (OIKOPLEURA)	29	193.3		
SALPA	348	2,320.0		
DOLIOLUM	2	13.3		
FISH EGGS	10	66.7		
BRACHYURAN LARVAE		1.7		
	415	2,768.3		

PLANKTON ANALYSIS

STATION FG-12 DATE December 1969 COLLECTED BY Fish & Game LAB NO. 05

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.4 CONCENTRATED VOLUME (ml) 20 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS SALPA

NUMBER OF ORGANISMS/M^3 1,862.5 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.06

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
MEDUSA	1	10.0		
CALANOID COPEPOD	28	280.0		
CYCLOPOID COPEPOD	1	10.0		
AMPHIPODS	1	10.0		
CHAETOGNATHS	3	30.0		
BRACHYURAN LARVAE	2	32.5		
LARVACEANS (OIKOPLEURA)	3	30.0		
SALPA	125	1,250.0		
FISH EGGS	21	210.0		
	185	1,862.5		

PLANKTON ANALYSIS

STATION FG-13 DATE December 1969 COLLECTED BY Fish & Game LAB NO. 06

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.5 CONCENTRATED VOLUME (ml) 40 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS SALPA

NUMBER OF ORGANISMS/M^3 1,826.0 NUMBER OF SPECIES 14 DIVERSITY INDEX 1.73

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
MEDUSA	2	16.0		
CALANOID COPEPOD	55	440.0		
CYCLOPOID COPEPOD	1	8.0		
AMPHIPOD	2	16.0		
EUPHAUSID SHRIMP	3	24.0		
POLYCHAETE LARVAE	1	8.0		
CHAETOGNATHS	1	8.0		
BRACHYURAN LARVAE	6	58.0		
SNAIL	1	8.0		
UNIDENTIFIED ORGANISM	1	8.0		
LARVACEANS (OIKOPLEURA)	7	56.0		
SALPA	127	1,016.0		
FISH EGGS	14	112.0		
FISH LARVAE	6	48.0		
	227	1,826.0		

PLANKTON ANALYSIS

STATION FG-9 DATE 2/15/70 COLLECTED BY Fish & Game LAB NO. 07

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.4 CONCENTRATED VOLUME (ml) no data ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M³ 6,089.4 NUMBER OF SPECIES 15 DIVERSITY INDEX 1.61

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON	-	-		
MEDUSA	2	5		
SIPHONOPHORE	7	17.5		
COPEPOD NAUPLIUS	1	2.2		
CALANOID COPEPOD	99	247.5		
CYCLOPOID COPEPOD	15	37.5		
AMPHIPODS	10	25		
MYSIDS	2	5		
SNAILS	1	2.2		
CHAETOGNATH	13	32.5		
LARVACEANS (OIKOPLEURA)	212	530		
SALPA	30	75		
THALIA (DEMOCRATIC)	2	5		
FISH EGGS	2,020	5,050		
FISH EMBRYO	19	47.5		
FISH LARVAE	3	7.5		
	2,436	6,089.4		

PLANKTON ANALYSIS

STATION FG-9 DATE 2/15/70 COLLECTED BY Fish & Game LAB NO. 08

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 70 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M^3 4,436.6 NUMBER OF SPECIES 16 DIVERSITY INDEX 1.79

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
MEDUSA	3	4.3		
SIPHONOPHORES	3	4.3		
COPEPOD NAUPLII	2	2.8		
CALANOID COPEODS	203	290		
CYCLOPOID COPEPODS	53	76		
BARNACLE NAUPLII	3	4.3		
MYSIDS	4	5.7		
EUPHAUSID SHRIMP	26	37		
BRACHUYRAN LARVAE	6	8.6		
SNAILS	6	8.6		
CHAETOGNATHS	6	8.6		
LARVACEANS (OIKOPLEURA)	500	714		
SALPA	225	321		
FISH EGGS	2,000	2,860		
FISH EMBRYOS	41	58.5		
FISH LARVAE	23	32.9		
	3,104	4,436.6		

PLANKTON ANALYSIS

STATION FG-10 DATE 2/15/70 COLLECTED BY Fish & Game LAB NO. 09

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) no data ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EMBRYO OIKOPLEURA CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 746.7 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.51

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
SIPHONOPHORE	2	2.9		
CALANOID COPEPOD	77	110		
CYCLOPOID COPEPOD	3	4.3		
AMPHIPOD	1	1.4		
CTENOPHORE	4	5.7		
ANNELID LARVAE	33	47.1		
BRACHYURAN LARVAE	2	2.9		
LARVACEANS (OIKOPLEURA)	165	235.7		
SALPS	45	64.3		
FISH EMBRYO	191	272.8		
FISH LARVAE	1	1.4		
	524	746.7		

PLANKTON ANALYSIS

STATION B | DATE 2/25/70 | COLLECTED BY Brown & Caldwell | LAB NO. 10

TOW TYPE 2M | TOW LENGTH | ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 4.62 | CONCENTRATED VOLUME (ml) 0.2 ml | ALIQUOT (ml) total | PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 4.12 | NUMBER OF SPECIES 4 | DIVERSITY INDEX 2.16

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYPOPLANKTON	-	-		
COPEPOD NAUPLII	1	0.22		
CALANOID COPEPODS	12	2.60		
CYCLOPOID COPEPODS	5	1.08		
FISH LARVAE	1	0.22		
	19	4.12		

PLANKTON ANALYSIS

STATION B DATE 2/25/70 COLLECTED BY Brown & Caldwell LAB NO. 11

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 4.62 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/16 total PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M³ 2,019.5 NUMBER OF SPECIES 15 DIVERSITY INDEX 1.84

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON	-	-		
MEDUSA	2	6.93		
CALANOID NAUPLII	28	96.97		
CALANOID COPEPOD	490	1,696.96		
CYCLOPOID COPEPOD	22	76.19		
BARNACLE NAUPLII	4	13.85		
BARNACLE LARVAE (CYPRIS)	4	13.85		
ANNELID LARVAE	4	13.85		
MYSIDS	2	6.93		
EUPHAUSIDS	4	13.85		
CHAETOGNATHS	4	13.85		
PORCELLANID	6	1.30		
BRACHYURAN LARVAE	220	47.62		
LARVACEANS (OIKOPLEURA)	2	6.93		
FISH EGGS	1	3.46		
FISH LARVAE	2	6.93		
	795	2,019.5		

PLANKTON ANALYSIS

STATION B DATE 2/25/70 COLLECTED BY Brown and Caldwell LAB NO. 12

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 4.62 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID COPEP BRACHYURAN LARVA

NUMBER OF ORGANISMS/M^3 113.4 NUMBER OF SPECIES 11 DIVERSITY INDEX 2.12

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
COPEPOD NAUPLII	12	9.52		
CALANOID COPEPOD	83	71.86		
CYCLOPID COPEPOD	2	1.73		
BARNACLE LARVAE	2	1.73		
ANNELID LARVAE	1	0.87		
EUPHAUSID	4	1.73		
PORCELLANID (total sample)	1	0.22		
BRACHYURAN LARVAE (total sample)	95	20.56		
CHAETOGNATHS	2	1.73		
LARVACEANS (OIKOPLEURA)	1	0.87		
FISH LARVAE	3	2.60		
	206	113.4		

PLANKTON ANALYSIS

STATION E DATE 2/25/70 COLLECTED BY Brown & Caldwell LAB NO. 13

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 4.62 CONCENTRATED VOLUME (ml) 1.5ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 442.2 NUMBER OF SPECIES 16 DIVERSITY INDEX 2.46

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	2	1.73		
EPHYRA LARVAE (giant jelly fish)	1	0.87		
COPEPOD NAUPLII	3	2.60		
CALANOID COPEPOD	431	373.16		
CYCLOPOID COPEPOD	8	6.93		
BARNACLE NAUPLII	15	13.0		
BARNACLE LARVAE	1	0.87		
ANNELID LARVAE	1	0.87		
EUPHAUSID	4	3.46		
CHAETOGNATH	6	5.20		
PORCELLANID (Total sample)	2	0.43		
BRACHYURAN LARVAE (total sample)	57	12.34		
ECHINODERM LARVAE	1	0.87		
LARVACEANS (OIKOPLEURA)	19	16.45		
FISH EGGS	2	1.73		
FISH LARVAE	2	1.73		
	555	442.2		

PLANKTON ANALYSIS

STATION E DATE 2/25/70 COLLECTED BY Brown & Caldwell LAB NO. 14

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 4.62 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID CY

NUMBER OF ORGANISMS/M^3 346.8 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.88

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
MEDUSA	8	6.93		
COPEPOD NAUPLII	22	19.05		
CALANOID COPEPOD	329	284.84		
CYCLOPOID COPEPOD	1	0.87		
BARNACLE LARVAE	1	0.87		
ANNELID LARVAE	1	0.87		
EUPHAUSID	2	1.73		
CHAETOGNATH	4	3.46		
BRACHYURAN LARVAE (total sample)	58	12.55		
LARVACEANS (OIKOPLEURA)	7	6.06		
FISH EGGS	2	1.73		
FISH LARVAE	9	7.79		
	444	346.8		

PLANKTON ANALYSIS

STATION FG-11 DATE 3/28/70 COLLECTED BY Fish & Game LAB NO. 15

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.8 CONCENTRATED VOLUME (ml) 0.2ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 741.8 NUMBER OF SPECIES 14 DIVERSITY INDEX 1.97

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	4	20.00		
SIPHONOPHORE	1	5.00		
COPEPOD NAUPLII	2	10.00		
CALANOID COPEPOD	126	617.50		
CYCLOPOID COPEPOD	1	5.00		
MYSID	1	5.00		
EUPHAUSID	1	5.00		
ANNELID LARVAE	1	5.00		
CHAETOGNATH	2	10.00		
BRACHYURAN LARVAE (total sample)	27	33.75		
GASTROPOD LARVAE	1	5.00		
ECHINODERM LARVAE	2	10.00		
LARVACEANS (OIKOPLEURA)	11	5.50		
FISH EGGS	1	5.00		
	181	741.8		

PLANKTON ANALYSIS

STATION FG-9 DATE 3/31/70 COLLECTED BY Fish & Game LAB NO. 17

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.1 CONCENTRATED VOLUME (ml) 0.01 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M^3 122.7 NUMBER OF SPECIES 3 DIVERSITY INDEX 0.42

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPODS	33	30.00		
LARVACEANS (OIKOPLEURA)	21	19.09		
FISH EGGS	81	73.64		
	135	122.7		

PLANKTON ANALYSIS

STATION FG-1 DATE 4/1/70 COLLECTED BY Fish & Game LAB NO. 18

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.9 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) 1/2 total PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 371.1 NUMBER OF SPECIES 3 DIVERSITY INDEX 0.34

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPODS	86	191.1		
BRACHYURAN LARVAE	1	2.2		
FISH EGGS	80	177.8		
	167	371.1		

PLANKTON ANALYSIS

STATION	FG-2	DATE	April 1970	COLLECTED BY	Fish & Game	LAB NO.	19
TOW TYPE	2M	TOW LENGTH		ANALYZED BY	S. Murray		
VOLUME SAMPLED (M^3)	0.5	CONCENTRATED VOLUME (ml)	0.1 ml	ALIQUOT (ml)	1/2 total	PREDOMINANT ORGANISMS	FISH EGGS
NUMBER OF ORGANISMS/M^3	608	NUMBER OF SPECIES	2	DIVERSITY INDEX	0.16		

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPODS	37	148.0		
FISH EGGS	115	460.0		
	152	608.0		

PLANKTON ANALYSIS

STATION FG-3 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 20

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M^3 1,424.4 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.96

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CALANOID COPEPODS	196	280.0		
EUPHAUSID CALYPTOSIS	2	2.9		
AMPHIPOD	1	1.4		
CHAETOGNATH	2	2.9		
LARVACEANS (OIKOPLEURA)	2	2.9		
FISH EGGS	791	1,130.0		
FISH LARVAE	2	2.9		
BRACHYURAN LARVAE	1	1.4		
	997	1,424.4		

PLANKTON ANALYSIS

STATION FG-4 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 21

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID CO

NUMBER OF ORGANISMS/M^3 1,519.9 NUMBER OF SPECIES 6 DIVERSITY INDEX 0.68

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPOD	242	1,382.8		
CYCLOPOID COPEPOD	2	11.4		
EUPHAUSID CALYPTOPIS	1	5.7		
BARNACLE NAUPLII	2	11.4		
BRACHYURAN LARVAE	1	5.7		
FISH EGGS	18	102.9		
	266	1,519.9		

PLANKTON ANALYSIS

STATION FG-5 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 22

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.5 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M^3 548 NUMBER OF SPECIES 4 DIVERSITY INDEX 0.48

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPODS	78	156.0		
CYCLOPOID COPEPOD	1	2.0		
FISH EGGS	193	386.0		
BRACHYURAN LARVAE	2	4.0		
	274	548.0		

PLANKTON ANALYSIS

STATION FG-9 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 23

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.9 CONCENTRATED VOLUME (ml) ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M^3 512.2 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.12

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CALANOID COPEPODS	52	57.8		
CYCLOPOID COPEPODS	7	7.8		
EUPHAUSID CALYPTOPIS	1	1.1		
SNAIL	2	2.2		
LARVACEANS (OIKOPLEURA)	8	8.9		
FISH EGGS	389	432.2		
FISH LARVAE	1	1.1		
BRACHYURAN LARVAE	1	1.1		
	461	512.2		

PLANKTON ANALYSIS

STATION FG-11 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 24

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.4 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 3,810 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.85

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CTENOPHORE	2	20.0		
CALANOID COPEPOD	345	3,450.0		
AMPHIPOD	2	20.0		
BRACHYURAN LARVAE	1	30.0		
CHAETOGNATHS	4	40.0		
LARVACEANS (OIKOPLEURA)	17	170.0		
FISH EGGS	7	70.0		
FISH LARVAE	1	10.0		
	379	3,810.0		

PLANKTON ANALYSIS

STATION FG-12 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 25

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.6 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID C

NUMBER OF ORGANISMS/M^3 1,740.1 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.47

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
MEDUSA	3	20.0		
CTENOPHORE	2	13.3		
SIPHONOPHORE	3	20.0		
CALANOID COPEPOD	215	1,433.3		
CYCLOPOID COPEPODS	6	40.0		
EUPHAUSID	1	6.7		
BARNACLE NAUPLII	1	6.7		
BRACHYURAN LARVAE	1	26.7		
CHAETOGNATH	4	26.7		
SNAIL	1	6.7		
LARVACEANS (OIKOPLEURA)	16	106.7		
FISH EGGS	5	33.3		
	258	1,740.1		

PLANKTON ANALYSIS

STATION FG-13 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 26

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.8 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 327.5 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.55

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
MEDUSA	2	2.5		
SIPHONOPHORE	1	1.2		
CALANOID COPEPOD	185	231.2		
CYCLOPOID COPEPOD	14	17.5		
BARNACLE NAUPLII	7	8.7		
BARNACLE LARVAE	3	3.8		
CHAETOGNATH	2	2.5		
BRACHYURAN LARVAE	3	3.8		
LARVACEANS (OIKOPLEURA)	18	22.5		
FISH EGGS	27	33.8		
	262	327.5		

PLANKTON ANALYSIS

STATION FG-14 DATE April 1970 COLLECTED BY Fish & Game LAB NO. 27

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.9 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID CO

NUMBER OF ORGANISMS/M^3 1,603.1 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.22

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
MEDUSA	1	4.4		
CALANOID COPEPOD	257	1,142.2		
CYCLOPOID COPEPOD	2	8.9		
BARNACLE NAUPLII	81	360.0		
EUPHAUSID	1	4.4		
EUPHAUSID FURCILIA	1	4.4		
CHAETOGNATH	3	13.3		
BRACHYURAN LARVAE	2	12.2		
LARVACEANS (OIKOPLEURA)	2	8.9		
FISH EGGS	10	44.4		
	360	1,603.1		

PLANKTON ANALYSIS

STATION FG-1 DATE 4/2/70 COLLECTED BY Fish & Game LAB NO. 28

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.0 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 263 NUMBER OF SPECIES 4 DIVERSITY INDEX 0.54

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPODS	140	140		
CYCLOPOID COPEPODS	2	2		
CHAETOGNATH	5	5		
FISH EGGS	116	116		
	263	263		

PLANKTON ANALYSIS

STATION FG-2 DATE 4/2/70 COLLECTED BY Fish & Game LAB NO. 29

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.3 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS CALANOID (

NUMBER OF ORGANISMS/M^3 570.00 NUMBER OF SPECIES 3 DIVERSITY INDEX 0.32

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPODS	95	316.67		
CHAETOGNATH	1	3.33		
FISH EGGS	75	250.00		
	171	570.00		

PLANKTON ANALYSIS

STATION FG-3 DATE 4/2/70 COLLECTED BY Fish & Game LAB NO. 30

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.6 CONCENTRATED VOLUME (ml) ALIQUOT (ml) 1/4 total or total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M³ 2,746.7 NUMBER OF SPECIES 6 DIVERSITY INDEX 0.63

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON	-	-		
CALANOID COPEPOD	9	60.00		
AMPHIPOD	1	6.67		
CHAETOGNATH	1	6.67		
ANOMURAN (total sample)	3	5.00		
BRACHYURAN LARVAE (total sample)	1	1.67		
FISH EGGS	400	2,666.67		
	415	2,746.7		

PLANKTON ANALYSIS

STATION FG-4 DATE April 2, 1970 COLLECTED BY Fish & Game LAB NO. 31

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) 1/4 total or total PREDOMINANT ORGANISMS CALANOID

NUMBER OF ORGANISMS/M^3 1,094.3 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.29

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPOD	165	942.85		
CYCLOPOID COPEPOD	1	5.71		
AMPHIPOD	1	5.71		
BARNACLE LARVAE	2	11.43		
EUPHAUSID	2	11.43		
CHAETOGNATH	3	17.14		
BRACHYURAN LARVAE (total sample)	2	2.86		
LARVACEANS (OIKOPLEURA)	7	40.00		
FISH EGGS	5	28.57		
FISH LARVAE	5	28.57		
	193	1,094.3		

PLANKTON ANALYSIS

STATION FG-5 DATE April 2, 1970 COLLECTED BY Fish & Game LAB NO. 32

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 431.4 NUMBER OF SPECIES 7 DIVERSITY INDEX 0.99

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON	-	-		
CALANOID COPEPODS	35	200.00		
CYCLOPOID COPEPODS	5	28.57		
MYSID	3	17.14		
CHAETOGNATHS	3	17.14		
BRACHYURAN LARVAE (total sample)	6	8.57		
FISH EGGS	27	154.28		
FISH LARVAE	1	5.71		
	80	431.4		

PLANKTON ANALYSIS

STATION FG-6 DATE April 1, 1970 COLLECTED BY Fish & Game LAB NO. 33

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.8 CONCENTRATED VOLUME (ml) 0.1 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M^3 1,275 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.98

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CALANOID COPEPOD	25	75.00		
ANNELID LARVAE	1	5.00		
CHAETOGNATH	3	15.00		
BRACHYURAN LARVAE (total sample)	4	5.00		
GASTROPOD LARVAE	1	5.00		
LARVACEANS (OIKOPLEURA)	3	15.00		
FISH EGGS	230	1,150.00		
FISH LARVAE	1	5.00		
	268	1,275.00		

PLANKTON ANALYSIS

STATION FG-7 DATE April 2, 1970 COLLECTED BY Fish & Game LAB NO. 34

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.0 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 454 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.14

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CALANOID COPEPODS	95	380		
CYCLOPOID COPEPODS	1	4		
AMPHIPODS	1	4		
CHAETOGNATH	1	4		
PORCELLANID (total sample)	1	1		
BRACHYURAN LARVAE (total sample)	9	9		
LARVACEANS (OIKOPLEURA)	1	4		
FISH EGGS	12	48		
	121	454		

PLANKTON ANALYSIS

STATION FG-8 DATE 4/2/70 COLLECTED BY Fish & Game LAB NO. 35

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 1.0 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID C

BRACHYURAN

NUMBER OF ORGANISMS/M³ 1,963 NUMBER OF SPECIES 15 DIVERSITY INDEX 1.85

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
MEDUSA	1	4		
SIPHONOPHORE	1	4		
CALANOID COPEPOD	346	1,384		
CYCLOPOID COPEPOD	6	24		
BARNACLE NAUPLII	2	8		
BARNACLE LARVAE	2	8		
EUPHAUSID	9	36		
MYSID	3	12		
CHAETOGNATHS	4	16		
PORCELLANID (total sample)	5	5		
BRACHYURAN LARVAE (total sample)	439	439		
GASTROPOD LARVAE	1	4		
LARVACEANS (OIKOPLEURA)	2	8		
FISH EGGS	2	8		
FISH LARVAE	2	8		
	825	1,963		

PLANKTON ANALYSIS

STATION FG-10 DATE 4/2/70 COLLECTED BY Fish & Game LAB NO. 36

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.8 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M³ 279.9 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.60

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
SIPHONOPHORE	1	1.25		
COPEPOD NAUPLII	1	1.25		
CALANOID COPEPOD	176	220.00		
CYCLOPOID COPEPOD	16	20.00		
ANNELID LARVAE	1	1.25		
CHAETOGNATH	16	20.00		
BRACHYURAN LARVAE	7	8.75		
LARVACEANS (OIKOPLEURA)	19	2.38		
FISH EGGS	3	3.75		
FISH LARVAE	1	1.25		
	241	279.9		

PLANKTON ANALYSIS

STATION FG-12 DATE 4/2/70 COLLECTED BY Fish & Game LAB NO. 37

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 0.1 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS BARNACLE L

NUMBER OF ORGANISMS/M^3 14.3 NUMBER OF SPECIES 3 DIVERSITY INDEX 0.76

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CALANOID COPEPODS	1	1.43		
CYCLOPOID COPEPODS	2	2.86		
BARNACLE LARVAE	7	10.00		
	10	14.3		

PLANKTON ANALYSIS

STATION FG-13 DATE 4/2/70 COLLECTED BY Fish & Game LAB NO. 38

TOW TYPE 10 M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.5 CONCENTRATED VOLUME (ml) 0.2 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS CYCLOPOID COPEPO

NUMBER OF ORGANISMS/M³ 478 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.78

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
MEDUSA	4	8		
SIPHONOPHORES	8	16		
COPEPOD NAUPLII	16	32		
CALANOID COPEPOD	16	32		
CYCLOPOID COPEPOD	76	152		
ANNALID LARVAE	4	8		
EUPHAUSID	4	8		
BRACHYURAN LARVAE	57	114		
BRACHYURAN MEGALOPS	3	6		
CLAM LARVAE	1	2		
LARVACEANS (OIKOPLEURA)	36	72		
FISH EGGS	1	2		
	239	478		

PLANKTON ANALYSIS

STATION FG-14 DATE 4/1/70 COLLECTED BY Fish & Game LAB NO. 39

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.0 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/4 total or total PREDOMINANT ORGANISMS CALANOID (

NUMBER OF ORGANISMS/M^3 2,073 NUMBER OF SPECIES 14 DIVERSITY INDEX 1.70

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	3	12		
SIPHONOPHORE	4	16		
CTENOPHORE	3	12		
COPEPOD LARVAE	100	400		
CALANOID COPEPOD	383	1,532		
CYCLOPOID COPEPOD	2	8		
BARNACLE LARVAE	2	8		
MYSID	1	4		
EUPHAUSID	3	12		
CHAETOGNATH	2	8		
BRACHYURAN LARVAE (total sample)	29	29		
CLAM LARVAE	1	4		
LARVACEANS (OIKOPLEURA)	5	20		
FISH EGGS	2	8		
	540	2,073		

PLANKTON ANALYSIS

STATION FG-9 DATE 5/16/70 COLLECTED BY Fish & Game LAB NO. 40

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.0 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) 1/2 total or total PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 83 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.58

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
VELLELA	1	1		
CALANOID COPEPOD	32	64		
CYLOPOID COPEPOD	1	2		
EUPHAUSID CALYPTOPIS	1	2		
EUPAHUSID ADULT	1	2		
FISH EGGS	3	6		
AMPHIPOD	1	2		
CLADOCERAN	2	4		
	43	83		

PLANKTON ANALYSIS

STATION FG-9 DATE 5/16/70 COLLECTED BY Fish & Game LAB NO. 41

TOW TYPE 10 TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.0 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/4 total or total PREDOMINANT ORGANISMS CALANOID CC

NUMBER OF ORGANISMS/M^3 1,534 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.23

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
SIPHONOPHORE (swimming bell)	1	4		
CTENOPHORES	2	2		
CALANOID COPEPODS	350	1420		
EUPHAUSID NAUPLII	8	32		
EUPHAUSID CALYPTOPIS	6	24		
EUPHAUSID	1	4		
AMPHIPOD	6	24		
BARNACLE NAUPLII	1	4		
CHAETOGNATH	2	8		
LARVACEANS (OIKOPLEURA)	3	12		
	380	1534		

PLANKTON ANALYSIS

STATION FG-11 DATE 5/16/70 COLLECTED BY Fish & Game LAB NO. 42

TOW TYPE 2 M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.2 CONCENTRATED VOLUME (ml) 15 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS FISH EGGS, CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 30,796 NUMBER OF SPECIES 10 DIVERSITY INDEX 0.87

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	1	40		
CALANOID COPEPOD	205	8200		
BARNACLE NAUPLII	3	120		
EUPHAUSID NAUPLII	4	160		
EUPHAUSID CALYPTOPIS	39	156		
EUPHAUSID FURCILIA	1	40		
LARVACEANS (OIKOPLEURA)	21	840		
FISH EGGS	526	21040		
BRACHYURAN LARVAE	3	120		
POLYCHAETE LARVAE	2	80		
	805	30796		

PLANKTON ANALYSIS

STATION FG-12 DATE 5/16/70 COLLECTED BY Fish & Game LAB NO. 43

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 1.0 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS CALANOID

NUMBER OF ORGANISMS/M³ 263 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.26

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
CALANOID COPEPOD	206	206		
BARNACLE NAUPLII	1	1		
EUPHAUSID CALYPTOPIS	7	7		
EUPHAUSID FURCILIA	2	2		
EUPHAUSID ADULT	1	1		
SNAIL	1	1		
LARVACEANS (OIKOPLEURA)	9	9		
FISH EGGS	36	36		
	263	263		

PLANKTON ANALYSIS

STATION FG-13 DATE 5/16/70 COLLECTED BY Fish & Game LAB NO. 44

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.2 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M³ 447 NUMBER OF SPECIES 8 DIVERSITY INDEX 1.15

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
CALANOID COPEPOD	338	338		
BARNACLE NAUPLII	1	1		
EUPHAUSID NAUPLII	5	5		
EUPHAUSID ADULT	1	1		
LARVACEANS (OIKOPLEURA)	39	39		
FISH EGGS	61	61		
SNAIL	1	1		
ROTIFER	1	1		
	447	447		

PLANKTON ANALYSIS

STATION FG-11 DATE 5/22/70 COLLECTED BY Fish & Game LAB NO. 45

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.2 CONCENTRATED VOLUME (ml) 40 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS CALANOID C

NUMBER OF ORGANISMS/M^3 34,440.0 NUMBER OF SPECIES 16 DIVERSITY INDEX 1.44

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	8	320.0		
SEA ANEMONE	1	40.0		
CALANOID COPEPOD	435	17,400.0		
BARNACLE METANAUPLII	15	600.0		
BARNACLE LARVAE	2	80.0		
EUPHAUSID METANAUPLII	57	2,280.0		
EUPHAUSID CALYPTOPIS	85	3,400.0		
EUPHAUSID FURCILIA	20	800.0		
EUPHAUSID	54	2,160.0		
CHAETOGNATH	4	160.0		
LARVACEANS (OIKOPLEURA)	21	840.0		
BRACHYURAN LARVAE	1	40.0		
FISH EGGS	154	6,160.0		
AMPHIPOD	1	40.0		
POLYCHAETE	2	80.0		
SALPA	1	40.0		
	861	34,440.0		

PLANKTON ANALYSIS

STATION	FG-12	DATE	5/22/70	COLLECTED BY	Fish & Game	LAB NO.	46
TOW TYPE	10M	TOW LENGTH		ANALYZED BY	S. Murray		
VOLUME SAMPLED (M^3)	1.0	CONCENTRATED VOLUME (ml)	1 ml	ALIQUOT (ml)	1/8 total	PREDOMINANT ORGANISMS	CALANOID COPEPO
NUMBER OF ORGANISMS/M^3	3,704	NUMBER OF SPECIES	13	DIVERSITY INDEX	1.46		

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CTENOPHORE	6	48		
CALANOID COPEPOD	298	2,384		
BARNACLE NAUPLII	6	48		
BARNACLE LARVAE	1	8		
EUPHAUSID	2	16		
EUPHAUSID CALYPTOPIS	43	344		
EUPHAUSID FURCILIA	2	16		
EUPHAUSID METANAUPLII	8	64		
PHORONIAL LARVAE	1	8		
BRACHYURAN LARVAE	3	24		
LARVACEANS (OIKOPLEURA)	12	96		
FISH EGGS	80	640		
POLYCHAETE LARVAE	1	8		
	463	3,704		

PLANKTON ANALYSIS

STATION FG-13 DATE 5/22/70 COLLECTED BY Fish & Game LAB NO. 47

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.2 CONCENTRATED VOLUME (ml) 10 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS CALANOID CO

NUMBER OF ORGANISMS/M^3 14,300 NUMBER OF SPECIES 17 DIVERSITY INDEX 1.67

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	5	200.0		
SIPHONOPHORE	1	40.0		
MOLGULA	8	320.0		
CALANOID COPEPOD	189	7,560.0		
BRACHYURAN LARVAE	6	240.0		
CHAETOGNATH	4	120.0		
BARNACLE NAUPLII	73	2,920.0		
BARNACLE LARVAE	12	480.0		
EUPHAUSID NAUPLII	3	120.0		
EUPHAUSID CALYPTOPIS	16	640.0		
EUPHAUSID FURCILIA	1	40.0		
EUPHAUSID ADULT	4	160.0		
LARVACEANS (OIKOPLEURA)	33	1,320.0		
WORM	1	40.0		
POLYCHAETE	2	80.0		
PHORONID	1	10.0		
SNAIL	1	10.0		
	360	14,300.0		

PLANKTON ANALYSIS

STATION FG-1 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 48

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.9 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M³ 1,133.2 NUMBER OF SPECIES 9 DIVERSITY INDEX 0.99

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
SIPHONOPHORE	2	2.2		
CALANOID COPEPOD	28	31.1		
EUPHAUSID CALYPTOPIS	2	2.2		
EUPHAUSID FURCILIA	1	1.1		
CHAETOGNATH	1	1.1		
SALPA	1	1.1		
SNAIL	1	1.1		
SEA ANEMONE	1	1.1		
FISH EGGS	983	1,092.2		
	1,020	1,133.2		

PLANKTON ANALYSIS

STATION FG-1 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 49

TOW TYPE 10 TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.9 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS EGGS

NUMBER OF ORGANISMS/M^3 981.0 NUMBER OF SPECIES 13 DIVERSITY INDEX 1.74

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
SIPHONOPHORE swimming bell	36	40.0		
LENSIA (S.P.)	8	8.9		
CTENOPHORE	1	1.1		
CALANOID COPEPOD	43	47.8		
EUPHAUSID NAUPLII	3	3.3		
AMPHIPOD	1	1.1		
TOMOPTERIS (POLYCHAETE)	1	1.1		
ECHINODERM BARREL LARVAE	2	2.2		
SEA URCHIN LARVAE	1	1.1		
TUNICATES	47	52.2		
DOLIOLUM	1	1.1		
EGGS	735	816.7		
FISH EGGS (big)	4	4.4		
	883	981.0		

PLANKTON ANALYSIS

STATION FG-2 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 50

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.8 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M³ 1,256.1 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.40

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
SIPHONOPHORES	5	6.2		
CALANOID COPEPOD	300	375.0		
BARNACLE NAUPLII	19	23.8		
EUPHAUSID CALYPTOPIS	2	2.5		
EUPHAUSID FURCILIA	1	1.2		
EUPHAUSID ADULT	2	2.5		
BRACHYURAN LARVAE	1	1.2		
SEA URCHIN LARVAE	1	1.2		
LARVACEANS (OIKOPLEURA)	2	2.5		
SALPA	1	1.2		
FISH EGGS	671	838.8		
	1,005	1,256.1		

PLANKTON ANALYSIS

STATION	FG-2	DATE	5/24/70	COLLECTED BY	Fish & Game	LAB NO.	51
TOW TYPE	10	TOW LENGTH		ANALYZED BY	S. Murray		
VOLUME SAMPLED (M^3)	0.9	CONCENTRATED VOLUME (ml)	2 ml	ALIQUOT (ml)	1/4 total	PREDOMINANT ORGANISMS	EGGS
NUMBER OF ORGANISMS/M^3	1,257.6	NUMBER OF SPECIES	11	DIVERSITY INDEX	1.40		

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
SIPHONOPHORE	1	4.4		
SIPHONOPHORE swimming bell	1	4.4		
CALANOID COPEPODS	48	213.3		
EUPHAUSID NAUPLII	2	8.9		
EUPHAUSID	2	8.9		
SNAILS	2	8.9		
UNIDENTIFIED ORGANISMS	3	13.3		
LARVACEANS (OIKOPLEURA)	7	31.1		
DOLIOLUM	1	444.0		
SALPA	7	31.1		
EGGS	200	888.9		
	274	1,257.6		

PLANKTON ANALYSIS

STATION FG-3 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 52

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.7 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/2 total PREDOMINANT ORGANISMS FISH EGGS, CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 5,097.1 NUMBER OF SPECIES 7 DIVERSITY INDEX 0.70

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CALANOID COPEPOD	753	3,151.4		
EUPHAUSID CALYPTOPIS	9	25.7		
EUPHAUSID FURCILIA	5	14.3		
EUPHAUSID ADULT	1	2.9		
BARNACLE NAUPLII	2	5.7		
AMPHIPOD	1	2.9		
FISH EGGS	1013	2,894.2		
	1782	5,097.1		

PLANKTON ANALYSIS

STATION FG-3 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 53

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.7 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID CO

NUMBER OF ORGANISMS/M³ 5,794.1 NUMBER OF SPECIES 14 DIVERSITY INDEX 1.50

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
LENSIA	3	17.1		
CALANOID COPEPOD	636	3,634.2		
EUPHAUSID CALYPTOPIS	19	108.6		
EUPHAUSID FURCILIA	4	22.9		
EUPHAUSID	8	45.7		
BARNACLE LARVAE	5	28.6		
CHAETOGNATH	5	28.6		
POLYCHAETE LARVAE	1	5.7		
SNAIL	12	68.6		
SEA URCHIN LARVAE	2	11.4		
LARVACEANS (OIKOPLEURA)	10	57.1		
DOLIOLUM	2	11.4		
EGGS	306	1,748.5		
FISH EGGS	1	5.7		
	1,014	5,794.1		

PLANKTON ANALYSIS

STATION FG-4 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 54

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.6 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/2 total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M³ 5,846.5 NUMBER OF SPECIES 14 DIVERSITY INDEX 1.50

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
MEDUSA	8	26.7		
CALANOID COPEPOD	501	1,670.0		
CYCLOPOID COPEPOD	1	3.3		
BARNACLE NAUPLII	7	23.3		
EUPHAUSID NAUPLII	1	3.3		
EUPHAUSID CALYPTOPIS	10	33.3		
EUPHAUSID FURCILIA	3	10.0		
AMPHIPOD	2	6.7		
BRACHYURAN	2	6.7		
CHAETOGNATH	1	3.3		
TOMOPTERIS	3	10.0		
SEA ANEMONE	1	3.3		
LARVACEANS (OIKOPLEURA)	1	3.3		
FISH EGGS	1,213	4,043.3		
	1,754	5,846.5		

PLANKTON ANALYSIS

STATION FG-4 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 55

TOW TYPE 10 TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.6 CONCENTRATED VOLUME (ml) 1.5 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS EGGS

NUMBER OF ORGANISMS/M^3 10,666.4 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.35

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CALANOID CYPEPOD	330	4,400.0		
EUPHAUSID NAUPLII	7	93.3		
EUPHAUSID CALYPTOPIS	52	693.3		
EUPHAUSID FURCILIA	21	280.0		
EUPHAUSID	46	613.3		
AMPHIPOD	2	26.7		
BARNACLE METANAUPLII	10	133.3		
TOMOPTERIS (POLYCHAETE)	1	13.3		
BRACHYURAN LARVAE	1	13.3		
CHAETOGNATH	1	13.3		
EGGS	329	4,386.6		
	800	10,666.4		

PLANKTON ANALYSIS

STATION FG-5 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 56

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.5 CONCENTRATED VOLUME (ml) 5 ml ALIQUOT (ml) 1/2 total PREDOMINANT ORGANISMS FISH EGGS

NUMBER OF ORGANISMS/M³ 7,076 NUMBER OF SPECIES 15 DIVERSITY INDEX 1.47

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
MEDUSA	6	24		
CALANOID COPEPOD	333	1,332		
CYCLOPOID COPEPOD	2	8		
EUPHAUSID CALYPTOPIS	346	1,384		
EUPHAUSID FURCILIA	67	268		
EUPHAUSID ADULT	3	12		
TOMOPTERIS	8	32		
POLYCHAETE LARVAE	1	4		
CHAETOGNATH	1	4		
AMPHIPOD	11	44		
BARNACLE NAUPLII	46	184		
ANOMURAN	1	4		
SNAIL	2	8		
LARVACEANS (OIKOPLEURA)	5	20		
FISH EGGS	937	3,748		
	1,769	7,076		

PLANKTON ANALYSIS

STATION FG-5 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 57

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 0.5 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS EGGS

NUMBER OF ORGANISMS/M³ 6,888.0 NUMBER OF SPECIES 13 DIVERSITY INDEX 1.36

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
MEDUSA	3	24.0		
CALANOID COPEPOD	573	4,584.0		
EUPHAUSID NAUPLII	18	144.0		
EUPHAUSID CALYPTOPIS	87	696.0		
EUPHAUSID FURCILIA	17	136.0		
EUPHAUSID	109	872.0		
AMPHIPOD	1	8.0		
BARNACLE NAUPLII	43	344.0		
BARNACLE LARVAE	1	8.0		
BRACHYURAN LARVAE	6	48.0		
SNAIL	2	16.0		
POLYCHAETE LARVAE	1	8.0		
EGGS	840			
	1,695	6,888.0		

PLANKTON ANALYSIS

STATION FG-14 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 58

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.6 CONCENTRATED VOLUME (ml) 1.5 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS BARNACLE META-NAUPLII

NUMBER OF ORGANISMS/M^3 4,024 NUMBER OF SPECIES 17 DIVERSITY INDEX 1.93

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	4	32		
SIPHONOPHORE	1	8		
CALANOID COPEPOD	105	840		
CYCLOPOID COPEPOD	2	16		
BARNACLE NAUPLII	320	2,560		
BARNACLE LARVAE	6	48		
EUPHAUSID NAUPLII	1	8		
EUPHAUSID CALYPTOPIS	8	64		
EUPHAUSID FURCILIA	2	16		
EUPHAUSID ADULT	2	16		
BRACHYURAN LARVAE	1	8		
TOMOPTERIS	1	8		
AMPHIPOD	1	8		
LARVACEANS (OIKOPLEURA)	28	224		
FISH EGGS	18	144		
CUMACEAN	1	8		
POLYCHAETE LARVAE	2	16		
	503	4,024		

PLANKTON ANALYSIS

STATION FG-14 DATE 5/24/70 COLLECTED BY Fish & Game LAB NO. 59

TOW TYPE 10M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 0.6 CONCENTRATED VOLUME (ml) 1.5 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS BARNACLE NA

NUMBER OF ORGANISMS/M^3 6,293.4 NUMBER OF SPECIES 17 DIVERSITY INDEX 1.83

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	9	60.0		
SIPHONOPHORE	1	6.7		
CTENOPHORE	4	26.7		
CALANOID COPEPOD	183	1,220.0		
EUPHAUSID CALYPTOPIS	7	46.7		
EUPHAUSID FURCILIA	3	20.0		
EUPHAUSID	1	6.7		
BARNACLE NAUPLII	633	4,220.0		
BARNACLE LARVAE	1	6.7		
POLYCHAETE LARVAE	35	233.3		
TOMOPTERIS	2	13.3		
CHAETOGNATH	5	33.3		
BRACHYURAN LARVAE	11	73.3		
PHORONIAL LARVAE	4	26.7		
SNAIL (heteropod)	1	6.7		
LARVACEANS (OIKOPLEURA)	38	253.3		
EGGS	6	40.0		
	944	6,293.4		

PLANKTON ANALYSIS

STATION Station E BC-1 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 60

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 478.3 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.30

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	492	347.08		
COPEPOD NAUPLII	60	42.33		
CALANOID COPEPOD	103	72.66		
CYCLOPOID COPEPOD	6	4.23		
BARNACLE LARVAE	7	4.94		
ANNELID LARVAE	3	2.12		
EUPHAUSID	1	0.71		
GASTROPOD LARVAE	5	3.53		
SEA URCHIN LARVAE	1	0.71		
	678	478.3		

PLANKTON ANALYSIS

STATION BC-3 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 61

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS CALANOID C

NUMBER OF ORGANISMS/M³ 767.5 NUMBER OF SPECIES 5 DIVERSITY INDEX 0.60

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
NOCTILUCA	300	211.64		
COPEPOD NAUPLII	110	77.60		
CALANOID COPEPOD	570	402.11		
ANNELID LARVAE	1	.71		
LARVACEANS (OIKOPLEURA)	101	75.48		
	1,088	767.5		

PLANKTON ANALYSIS

STATION BC-4 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 62

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS COPEPOD NAUPLII

NUMBER OF ORGANISMS/M³ 1,604 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.94

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
NOCTILUCA	684	482.53		
TINTINNID	108	76.19		
COPEPOD NAUPLII	916	646.20		
CALANOID COPEPOD	415	292.76		
EUPHAUSID NAUPLII	129	91.00		
ANNELID LARVAE	8	5.64		
CHAETOGNATH	1	0.71		
LARVACEANS (OIKOPLEURA)	13	9.17		
	2,274	1,604		

PLANKTON ANALYSIS

STATION BC-5 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 63

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 1,675.5 NUMBER OF SPECIES 7 DIVERSITY INDEX 0.80

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	845	1,192.23		
TINTINNID	25	35.27		
COPEPOD NAUPLII	149	210.93		
CALANOID COPEPOD	93	131.22		
EUPHAUSID NAUPLII	33	46.56		
ANNELID LARVAE	8	11.29		
LARVACEANS (OIKOPLURA)	34	47.97		
	1,187	1,675.5		

PLANKTON ANALYSIS

STATION BC-6 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 64

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/16 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 1,659 NUMBER OF SPECIES 6 DIVERSITY INDEX 0.67

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	238	671.60		
TINTINNID	12	33.86		
COPEPOD NAUPLII	83	234.21		
CALANOID COPEPOD	153	431.74		
EUPHAUSID NAUPLII	88	248.32		
LARVACEANS (OIKOPLEURA)	14	39.51		
	588	1,659		

PLANKTON ANALYSIS

STATION BC-7 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 65

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/16 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M³ 2,207 NUMBER OF SPECIES 8 DIVERSITY INDEX 0.91

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
NOCTILUCA	580	1,636.68		
TINTINNID	29	81.83		
COPEPOD NAUPLII	6	16.93		
CALANOID COPEPOD	63	177.77		
EUPHAUSID NAUPLII	78	220.10		
ANNELID LARVAE	1	2.82		
SEA URCHIN LARVAE	5	14.11		
LARVACEANS (OIKOPLEURA)	20	56.44		
	782	2,207		

PLANKTON ANALYSIS

STATION BC-8 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 66

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/16 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M³ 10,904 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.08

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
MEDUSA	2	5.64		
NOCTILUCA	2,350	6,631.39		
TINTINNID	93	262.43		
COPEPOD NAUPLII	292	823.98		
CALANOID COPEPOD	884	2,495.94		
BARNACLE NAUPLII	20	56.44		
EUPHAUSID NAUPLII	152	428.92		
EUPHAUSID	1	2.82		
ANNELID LARVAE	5	14.11		
SEA URCHIN LARVAE	5	14.11		
LARVACEANS (OIKOPLEURA)	59	168.25		
	3,863	10,904		

PLANKTON ANALYSIS

STATION BC-11 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 67

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/16 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 1,978 NUMBER OF SPECIES 14 DIVERSITY INDEX 1.71

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	300	846.56		
TINTINNID	2	5.64		
COPEPOD NAUPLII	42	118.52		
CALANOID COPEPOD	229	646.21		
BARNACLE LARVAE	8	22.57		
EUPHAUSID NAUPLII	36	102.29		
ANNELID LARVAE	6	16.93		
CHAETOGNATH	1	2.82		
GASTROPOD LARVAE	51	143.92		
SEA URCHIN LARVAE	7	14.11		
LARVACEANS (OIKOPLEURA)	5	30.34		
FISH EMBRYO	21	5.64		
FISH LARVAE	2	2.82		
CLAM LARVAE	1	19.75		
	711	1978		

PLANKTON ANALYSIS

STATION BC-13 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 68

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 5.67 CONCENTRATED VOLUME (ml) 1 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M³ 851 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.33

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
NOCTILUCA	351	445.23		
TINTINNID	8	11.29		
COPEPOD NAUPLII	62	87.48		
CALANOID NAUPLII	110	155.20		
BARNACLE NAUPLII	30	155.20		
EUPHAUSID NAUPLII	15	21.16		
ANNELID LARVAE	4	5.64		
BRACHYURAN LARVAE	1	1.41		
GASTROPOD LARVAE	8	11.29		
LARVACEANS (OIKOPLEURA)	14	19.75		
	603	851		

PLANKTON ANALYSIS

STATION BC-14 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 69

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 5.67 CONCENTRATED VOLUME (ml) 11 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 803.0 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.20

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	456	643.39		
TINTINNIDS	17	23.99		
COPEPOD NAUPLII	13	18.34		
CALANOID COPEPODS	40	56.61		
CYCLOPOID COPEPODS	9	12.70		
BARNACLE NAUPLII	25	35.27		
FLATWORM LARVAE	6	8.47		
ANNELID LARVAE	2	2.82		
LARVACEANS (OIKOPLEURA)	1	1.41		
	569	803.0		

PLANKTON ANALYSIS

STATION BC-77 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 70

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 5.67 CONCENTRATED VOLUME (ml) 2 ml ALIQUOT (ml) 1/16 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 2,207 NUMBER OF SPECIES 12 DIVERSITY INDEX 1.43

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	822	1156.97		
TINTINNID	4	5.64		
COPEPOD NAUPLII	144	203.17		
CALANOID COPEPOD	364	513.58		
CYCLOPOID COPEPOD	10	14.11		
BARNACLE NAUPLII	80	112.87		
EUPHAUSID NAUPLII	14	19.75		
ANNELID LARVAE	38	53.62		
CHAETOGNATH	6	8.46		
GASTROPOD LARVAE	38	53.62		
SEA URCHIN LARVAE	2	2.82		
	1,522	2,207		

PLANKTON ANALYSIS

STATION BC-88 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 71

TOW TYPE 2M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 5.67 CONCENTRATED VOLUME (ml) 0.5 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS CALANOID COP

NUMBER OF ORGANISMS/M³ 1,343 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.25

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
NOCTILUCA	206	290.65		
TINTINNID	93	131.22		
COPEPOD NAUPLII	16	163.67		
CALANOID COPEPODS	42	592.59		
BARNACLE LARVAE	6	8.47		
EUPHAUSID NAUPLII	98	138.27		
ANNELID LARVAE	2	2.82		
GASTROPOD LARVAE	2	2.82		
CLAM LARVAE	2	2.82		
LARVACEANS (OIKOPLEURA)	7	9.88		
	474	1,343		

PLANKTON ANALYSIS

STATION BC-100 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 72

TOW TYPE 8M TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 5.67 CONCENTRATED VOLUME (ml) N.D. (dirt) ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 251 NUMBER OF SPECIES 6 DIVERSITY INDEX 0.90

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	110	155.20		
TINTINNID	10	1r.11		
COPOPOD NAUPLII	11	15.32		
CALANOID COPEPOD	17	23.99		
BARNACLE NAUPLII	27	38.10		
LARVACEANS (OIKOPLEURA)	3	4.23		
	178	251		

PLANKTON ANALYSIS

STATION BC-2V DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 74

TOW TYPE Vertical TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) 1.34 CONCENTRATED VOLUME (ml) 5 M ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS CALANOID C(

NUMBER OF ORGANISMS/M³ 8,928 NUMBER OF SPECIES 13 DIVERSITY INDEX

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
MEDUSA	2	16		
CTENOPHORES	5	40		
NOCTILUCA	26	208		
COPEPOD NAUPLII	8	64		
CALANOID COPEPODS	974	7,792		
CYCLOPOID COPEPODS	3	24		
BARNACLE NAUPLII	21	168		
BARNACLE LARVAE	1	8		
AMPHIPOD	1	8		
ANNELID LARVAE	19	152		
EUPHAUSID	1	8		
CLAM LARVAE	1	8		
LARVACEANS (OIKOPLEURA)	54	432		
	1,116	8,928		

PLANKTON ANALYSIS

STATION BC-IV DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 73

TOW TYPE Vertical TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M³) .89 CONCENTRATED VOLUME (ml) N.D. (dirt) ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M³ 1,424 NUMBER OF SPECIES 13 DIVERSITY INDEX

DENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKTON				
NOCTILUCA	1098	8784		
COPEPOD NAUPLII	16	124		
CALANOID COPEPOD	628	5024		
CYCLOPOID COPEPOD	1	8		
AMPHIPOD	5	40		
BARNACLE NAUPLII	711	5688		
BARNACLE LARVAE	8	64		
FLATWORM LARVAE	1	8		
ANNELID LARVAE	11	88		
ANOMURAN LARVAE	3	24		
GASTROPOD LARVAE	1	8		
ECHINODERM BIPINNARIA	1	8		
FISH EGGS	2	16		
	2486	1424		

PLANKTON ANALYSIS

STATION BC-3V DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 75

TOW TYPE Vertical TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) .89 CONCENTRATED VOLUME (ml) N.D.(dirt) ALIQUOT (ml) 1/4 total PREDOMINANT ORGANISMS NOCTILUCA

NUMBER OF ORGANISMS/M^3 8,324 NUMBER OF SPECIES 15 DIVERSITY INDEX

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSA	2	8		
NOCTILUCA	1,289	5,156		
COPEPOD NAUPLII	12	48		
CALANOID COPEPOD	502	2,008		
CYCLOPOID COPEPOD	1	4		
BARNACLE NAUPLII	225	900		
BARNACLE LARVAE	7	28		
PHORONIAL LARVAE	1	4		
ANNELID LARVAE	6	24		
EUPHAUSID	2	8		
CUMACEANS	5	20		
CHAETOGNATH	1	4		
BRACHYURAN LARVAE	4	16		
LARVACEANS (OIKOPLEURA)	48	192		
FISH EGGS	1	4		
	2,106	8,324		

PLANKTON ANALYSIS

STATION BC-4V DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 76

TOW TYPE Vertical TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.34 CONCENTRATED VOLUME (ml) 6 ml ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 10,328 NUMBER OF SPECIES 14 DIVERSITY INDEX

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
CTENOPHORE	2	16		
NOCTILUCA	117	936		
COPEPOD NAUPLII	10	80		
CALANOID COPEPOD	1,105	8,840		
BARNACLE NAUPLII	17	136		
BARNACLE LARVAE	2	16		
ANNELID LARVAE	6	48		
EUPAHUSID	2	16		
CUMACEAN	1	8		
ANOMURAN LARVAE	1	8		
BRACHYURAN LARVAE	1	8		
SEA URCHIN LARVAE	2	16		
STAR FISH LARVAE	1	8		
LARVACEANS (OIKOPLEURA)	24	192		
	1,291	10,328		

PLANKTON ANALYSIS

STATION BC-5V DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 77

TOW TYPE Vertical TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) 1.34 CONCENTRATED VOLUME (ml) N.D.(dirt) ALIQUOT (ml) 1/16 total or total PREDOMINANT ORGANISMS CALANOID CO

NUMBER OF ORGANISMS/M^3 16,505 NUMBER OF SPECIES 8 DIVERSITY INDEX

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
MEDUSAE (total sample)	1	12		
CTENOPHORE (total sample)	3	45		
NOCTILUCA	57	912		
COPEPOD NAUPLII	18	288		
CALANOID COPEPOD	890	14,240		
BARNACLE NAUPLII	36	576		
ANNELID LARVAE	10	160		
LARVACEANS (OIKOPLEURA)	17	272		
	1,032	16,505		

PLANKTON ANALYSIS

STATION BC-6V DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 78

TOW TYPE Vertical TOW LENGTH ANALYZED BY S. Murray

VOLUME SAMPLED (M^3) .89 CONCENTRATED VOLUME (ml) N.D. (dirt) ALIQUOT (ml) 1/8 total PREDOMINANT ORGANISMS CALANOID COPEPODS

NUMBER OF ORGANISMS/M^3 12,728 NUMBER OF SPECIES 12 DIVERSITY INDEX

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
NOCTILUCA	187	1,496		
COPEPOD NAUPLII	20	160		
CALANOID COPEPOD	865	6,920		
BARNACLE NAUPLII	446	3,568		
BARNACLE LARVAE	5	40		
AMPHIPOD	1	8		
ANNELID LARVAE	21	168		
CUMACEAN	8	64		
EUPHAUSID	1	8		
CHAETOGNATH	2	16		
SEA URCHIN LARVAE	1	8		
LARVACEANS (OIKOPLEURA)	34	272		
	1,591	12,728		

PLANKTON ANALYSIS

STATION F DATE 10/5/70 COLLECTED BY Brown & Caldwell LAB NO. 79

TOW TYPE 3 M TOW LENGTH 5 min ANALYZED BY Bailey

VOLUME SAMPLED (M^3) 8.1 CONCENTRATED VOLUME (ml) 250 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 651.2 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.54

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
ANNELID LARVAE	15	46.3		
CALANOID COPEPOD	50	154.3		
CYCLOPOID COPEPOD	1	3.1		
HARPACTICOID COPEPOD	5	15.4		
COPEPOD NAUPLII	68	209.8		
BARNACLE NAUPLII	22	67.9		
CLADOCERAN	7	21.6		
CHAETOGNATH	24	74.1		
LARVACEANS (OIKOPLEURA)	8	24.7		
PELECYPOD LARVAE	7	21.6		
GASTROPOD LARVAE	4	12.4		
	211	651.2		

PLANKTON ANALYSIS

STATION	F	DATE	10/5/70	COLLECTED BY	Brown & Caldwell	LAB NO.	80
TOW TYPE	2M	TOW LENGTH	5 min	ANALYZED BY	Glimme		
VOLUME SAMPLED (M³)	8.1	CONCENTRATED VOLUME (ml)	340	ALIQUOT (ml)	10	PREDOMINANT ORGANISMS	CALANOID COPEPOD
NUMBER OF ORGANISMS/M³	1,750.5	NUMBER OF SPECIES	12	DIVERSITY INDEX	1.47		

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHYTOPLANKON				
ANNELID LARVAE	42	176.3		
CALANOID COPEPOD	181	759.8		
HARPACTICOID COPEPOD	22	92.4		
COPEPOD NAUPLII	41	172.1		
BARNACLE NAUPLII	30	125.9		
BARNACLE LARVAE	3	12.6		
CLADOCERAN	8	33.6		
BRACHYURAN MEGALOPA	1	4.2		
EUPHAUSID ADULT	1	4.2		
LARVACEANS (OIKOPLEURA)	58	243.5		
PELECYPOD LARVAE	28	117.5		
GASTROPOD LARVAE	2	8.4		
	417	1,750.5		

PLANKTON ANALYSIS

STATION D DATE 10/5/70 COLLECTED BY Brown & Caldwell LAB NO. 81

TOW TYPE 8M TOW LENGTH 5 min ANALYZED BY Glimme

VOLUME SAMPLED (M^3) 8.1 CONCENTRATED VOLUME (ml) 240 ml ALIQUOT (ml) 10ml PREDOMINANT ORGANISMS COPEPOD N[U] CALANOID [C]

NUMBER OF ORGANISMS/M^3 974.8 NUMBER OF SPECIES 11 DIVERSITY INDEX 1.45

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
ANNELIA LARVAE	6	17.8		
CALANOID COPEPOD	118	349.6		
CYCLOPOID COPEPOD	2	5.9		
HARPACTICOID COPEPOD	19	56.3		
COPEPOD NAUPLII	120	355.6		
BARNACLE NAUPLII	23	68.1		
BARNACLE LARVAE	10	29.6		
CLADOCERAN	17	50.4		
PELECYPOD LARVAE	12	35.5		
GASTROPOD LARVAE	1	3.0		
NEMATODE	1	3.0		
	329	974.8		

PLANKTON ANALYSIS

STATION F DATE 10/5/70 COLLECTED BY Brown & Caldwell LAB NO. 82

TOW TYPE 8M TOW LENGTH 5 min ANALYZED BY Bailey

VOLUME SAMPLED (M^3) 8.1 CONCENTRATED VOLUME (ml) 300 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS CALANOID COPEPO

NUMBER OF ORGANISMS/M^3 966.7 NUMBER OF SPECIES 10 DIVERSITY INDEX 1.31

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
ANNELID LARVAE	12	44.4		
CALANOID COPEPOD	149	551.9		
CYCLOPOID COPEPOD	3	11.1		
HARPACTICOID COPEPODS	7	25.9		
COPEPOD NAUPLII	43	159.3		
BARNACLE NAUPLII	18	66.7		
BARNACLE LARVAE	2	7.4		
CHAETOGNATH	6	22.2		
LARVACEANS (OIKOPLEURA)	17	63.0		
PELECYPOD LARVAE	4	14.8		
	261	966.7		

PLANKTON ANALYSIS

STATION D DATE 10/5/70 COLLECTED BY Brown & Caldwell LAB NO. 83

TOW TYPE 8M TOW LENGTH 5 min ANALYZED BY Glimme

VOLUME SAMPLED (M^3) 8.1 CONCENTRATED VOLUME (ml) 296 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS CALANOID C

NUMBER OF ORGANISMS/M^3 866.3 NUMBER OF SPECIES 16 DIVERSITY INDEX 2.22

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
ANNELID LARVAE	27	98.7		
HALACARIDAE	1	3.7		
CALANOID COPEPOD	71	259.4		
CYCLOPOID COPEPOD	3	11.0		
HARPACTICOID COPEPOD	3	11.0		
COPEPOD NAUPLII	15	54.8		
EUPHAUSID ADULT	5	18.3		
AMPHIPOD	1	3.7		
BARNACLE NAUPLII	10	36.5		
BARNACLE LARVAE	22	80.4		
CLADOCERA	48	175.4		
LARVACEANS (OIKOPLEURA)	18	65.8		
CHAETOGNATH	4	14.6		
PELECYPOD LARVAE	7	25.6		
GASTROPOD	1	3.7		
NEMATODE	1	3.7		
	237	866.3		

PLANKTON ANALYSIS

STATION D DATE 10/5/70 COLLECTED BY Brown & Caldwell LAB NO. 84

TOW TYPE 5M TOW LENGTH 5 min ANALYZED BY Bailey

VOLUME SAMPLED (M^3) 8.1 CONCENTRATED VOLUME (ml) 300 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS CALANOID COPEPOD

NUMBER OF ORGANISMS/M^3 800.0 NUMBER OF SPECIES 13 DIVERSITY INDEX 1.80

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
ANNELID LARVAE	19	70.4		
CALANOID COPEPODS	105	388.9		
HARPACTICOID COPEPODS	15	55.6		
COPEPOD NAUPLII	21	77.8		
BARNACLE NAUPLII	15	55.6		
BARNACLE LARVAE	1	3.7		
CLADOCERA	4	14.8		
EUPHAUSID ADULT	2	7.4		
CHAETOGNATH	10	37.0		
LARVACEANS (OIKOPLEURA)	12	44.4		
PELECYPOD LARVAE	9	33.3		
GASTROPOD	2	7.4		
NEMATODE	1	3.7		
	216	800.0		

PLANKTON ANALYSIS

STATION F DATE 10/5/70 COLLECTED BY Brown & Caldwell LAB NO. 85

TOW TYPE 5M TOW LENGTH 5 min ANALYZED BY Bailey

VOLUME SAMPLED (M^3) 8.1 CONCENTRATED VOLUME (ml) 250 ALIQUOT (ml) 10 PREDOMINANT ORGANISMS CALANOID CO

NUMBER OF ORGANISMS/M^3 799.4 NUMBER OF SPECIES 9 DIVERSITY INDEX 1.20

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PHYTOPLANKTON				
ANNELID LARVAE	3	9.3		
CALANOID COPEPOD	92	283.9		
HARPACTICOID COPEPOD	17	52.5		
COPEPOD NAUPLII	114	351.8		
BARNACLE NAUPLII	10	30.9		
CHAETOGNATH	8	24.7		
LARVACEANS (OIKOPLEURA)	4	12.3		
PELECYPOD LARVAE	10	30.9		
NEMATODE	1	3.1		
	259	799.4		

Benthic Studies

Reference: Fig. 5-27

June, 1964

FAUNAL LISTS AND SAMPLE WEIGHTS

Sample 1611

Total sample weight: 268 grams

Percentage of organic hard parts in sample: 0.4%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 2 individuals
Nonionella sp.	- 1 "

Phylum ARTHROPODA
Class Crustacea
ostracods

Pseudophilomedes sp.	- 12 individuals

Phylum MOLLUSCA
Class Bivalvia

Nuculana sp. juv.	- 1 individuals
Mysella tumida	- 24 "

Class Gastropoda

Nassarius sp.	- 1 individuals

"WORMS"

chitinous worm tubes	- few

Sample 1613

Total sample weight: 497 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

<u>Elphidiella</u> <u>hannai</u>	- 40 individuals
<u>Nonionella</u> sp.	- 2 "

Phylum ARTHROPODA
Class Crustacea

ostracods	
<u>Pseudophilomedes</u> sp.	- 1 individuals
<u>Rutiderma</u> sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

<u>Nuculana</u> <u>taphria</u>	- 1 individuals
<u>Siliqua</u> sp.	- 1 "
<u>Tellina</u> <u>carpenteri</u>	- 7 "
<u>Macoma</u> <u>yoldiformis</u>	- 1 "
<u>Spisula</u> cf. <u>S.</u> <u>catilliformis</u>	- 1 "
<u>Mysella</u> <u>tumida</u>	- 7 "
<u>Macoma</u> sp.	- 1 "

Class Scaphopoda

<u>Cadulus</u> <u>fusiformis</u>	- 1 individuals

Class Gastropoda

<u>Mitrella</u> <u>gouldii</u>	- 6 individuals
<u>Odostomia</u> sp. juv.	- 1 "
<u>Turbonilla</u> sp.	- 2 "

"WORMS"

chitinous worm tubes	- abundant

Phylum VERTEBRATA

vertebrae	- one specimen

Sample 1615

Total sample weight: 233 grams

Percentage of organic hard parts in sample: 2.8%

Phylum PROTISTA

Order Foraminifera

Haplophragmoides sp.	- 60 individuals
Elphidiella hannai	- 60 "
Massilina sp.	- 6 "
Poroeponides sp.	- 4 "
Triloculina sp.	- 8 "
Rotorbinella sp.	- 2 "

Phylum BRYOZOA (Entoprocta and Ectoprocta)

several genera

Phylum ARTHROPODA

Class Crustacea

barnacles	
Balanus sp.	- 9 individuals
crabs	
Cancer sp.	- 5 "

Phylum BRACHIOPODA

Terebratulina unguicola	- 2 individuals

Phylum MOLLUSCA

Class Amphineura

Mopalia sp.	- 1 individuals

Class Bivalvia

Nuculana taphria	- 7 individuals
Chlamys hastatus	- 1 "
Hinnites multirugosus	- 2 "
Modiolus sp. juv.	- 4 "
Transennella tantilla	- 4 "

Sample 1615 cont.

Kellis sp. ?	- 1 individuals	
Glans carpenteri	- 1 "	
Protothaca staminea	- 6 "	, mostly juveniles
Clinocardium fucanum	- 1 "	
Mya cf. M. truncata	- 6 "	
Spisula cf. S. catilliformis	- 2 "	
Mysella tumida	- 26 "	
Macoma secta	- 3 "	
Macoma inconspicua	- 1 "	
Nettastomella rostrata	- 8 "	

Class Gastropoda

Crepidula sp. juv.	- 3 individuals
Nassarius mendicus	- 15 "
Ocenebra sp. juv.	- 1 "
Bittium eschrichtii	- 1 "
Amphissa sp.	- 1 "
Turbonilla sp.	- 2 "
Odostomia sp. juv.	- 6 "
Alvania acutilirata	- 4 "
Cypraeolina pyriformis	- 1 "

"WORMS"

calcareous worm tubes	- 2 individuals

Sample 1617

Total sample weight: 1258 grams

Percentage of organic hard parts in sample: 0.5%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 17 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

three genera

Phylum ARTHROPODA

Class Crustacea

ostracods	
Pseudophilomedes sp.	- 1 individuals
barnacles	
Balanus sp.	- 5 "
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA

Class Bivalvia

Nuculana taphria	- 2 individuals
Hinnites multirugosus	- 4 "
Ostrea lurida	- 1 "
Protothaca staminea	- 9 "
Clinocardium nuttallii	- 2 "
Clinocardium fucanum	- 3 "
Transennella tantilla	- 45 "
Mysella tumida	- 3 "
Mya cf. M. truncata	- 3 "
Macoma secta	- 1 "

Class Scaphopoda

Cadulus fusiformis	- 1 individuals

Sample 1617 cont.

Class Gastropoda

Crepipatella sp. juv.	- 2 individuals
Margarites sp. ?	- 4 "
Homalopoma sp. ?	- 1 "
Nassarius mendicus	- 12 "
Ocenebra sp.	- 1 "
Alvania acutilirata	- 12 "
Mitrella sp.	- 1 "
Epitonium sp.	- 1 "
Balcis sp.	- 1 "
Turbonilla sp.	- 3 "

Sample 1618

Total sample weight: 1214 grams

Percentage of organic hard parts in sample: 10.5%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 85 individuals
Massilina sp.	- 1 "

Phylum ARTHROPODA
Class Crustacea

ostracods	
Mutilus (*Aurila*) sp.	- 1 individuals
barnacles	
Balanus sp.	- 2 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Chlamys sp.	- 1 individuals
Protothaca staminea	- 2 "
Clinocardium nuttallii	- 2 "
Kellia laperousii	- 1 "
Transennella tantilla	- 4 "
Mysella tumida	- 2 "
Mya cf. *M. truncata*	- 1 "
Tellina bodegensis	- 1 "

Class Gastropoda

Polytropa lamellosa	- 3 individuals
Olivella baetica	- 3 "
Nassarius mendicus	- 6 "
Nassarius cf. *N. perpinguis*	- 1 "
Alvania acutilirata	- 5 "
Epitonium sp.	- 1 "
Odostomia sp.	- 1 "
Turbonilla sp.	- 1 "
Mangelia barbarensis	- 1 "
Acteon ? sp.	- 1 "

Sample 1618 cont.

Phylum VERTEBRATA

vertebrae	- one specimen
fish dermal plate	- one specimen

Sample 1627

Total sample weight: 245 grams

Percentage of organic hard parts in sample: 0.6%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 7 individuals

Phylum ARHTROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 2 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Mysella tumida	- 12 individuals
Axinopsida sericata	- 1 "

Class Gastropoda

Mitrella sp.	- 1 individuals

"WORMS"

Chitinous worm tubes	- few

Miscellaneous plant fragments

Sample 1628

Total sample weight: 487 grams

Percentage of organic hard parts in sample: 0.3%

Phylum PROTISTA	
Order Foraminifera	
Elphidiella hannai	- 50 individuals
Phylum ARTHROPODA	
Class Crustacea	
ostracods	
Pseudophilomedes	- 5 individuals
crabs	
Cancer sp.	- 1 "
Phylum MOLLUSCA	
Class Bivalvia	
Mysella tumida	- 55 individuals
Axinopsida sericata	- 1 "
Tellina carpenteri	- 6 "
Class Gastropoda	
Mitrella gouldii	- 4 individuals
Nassarius perpinguis	- 1 "
Turbonilla sp.	- 2 "
"WORMS"	
chitinous worm tubes	- abundant
agglutinated worm tubes	- few

Sample 1629

Total sample weight: 1152 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 95 individuals
Massilina sp.	- 2 "

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 7 individuals
Rutiderma sp.	- 1 "
barnacles	
Balanus sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 6 individuals
Protothaca tenerrima	- 1 "
Spisula cf. S. catilliformis	- 1 "
Mysella tumida	- 24 "
Axinopsida sericata	- 4 "
Tellina bodegensis	- 10 "

Class Scaphopoda

Cadulus fusiformis	- 2 individuals

Class Gastropoda

Nassarius mendicus	- 2 individuals
Mitrella gouldii	- 1 "
Odostomia sp.	- 1 "
Mangelia barbarensis	- 1 "
Acteon punctocoelata	- 1 "

"WORMS"

chitinous worm tubes	- abundant

Sample 1633

Total sample weight: 826 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA	
Order Foraminifera	
Elphidiella hannai	- 30 individuals
Phylum ARTHROPODA	
Class Crustacea	
ostracods	
Pseudophilomedes sp.	- 7 individuals
barnacles	
Balanus sp.	- 1 "
crabs	
Cancer sp.	- 1 "
Phylum MOLLUSCA	
Class Bivalvia	
Modiolus sp. juv.	- 1 individuals
Siliqua sp.	- 1 "
Mysella tumida	- 6 "
Axinopsida sericata	- 1 "
Tellina bodegensis	- 11 "
Class Gastropoda	
Mitrella gouldii	- 3 individuals
Cypraeolina sp.	- 1 "
"WORMS"	
chitinous worm tubes	- abundant

Sample 1634

Total sample weight: 795 grams

Percentage of organic hard parts in sample: 0.1%

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA

Class Crustacea

ostracods

Pseudophilomedes sp.	- 3 individuals

Phylum MOLLUSCA

Class Bivalvia

Nuculana taphria	- 2 individuals
Spisula cf. S. catilliformis	- 2 "
Mysella tumida	- 3 "
Mysella sp.	- 1 "
Tellina bodegensis	- 5 "

"WORMS"

worm jaws	- 1 specimen
chitinous worm tubes	- abundant
agglutinated worm tubes	- few

Sample 1635

Total sample weight: 1157 grams

Percentage of organic hard parts in sample: 0.1%

Phylum PROTISTA	
Order Foraminifera	
Elphidiella hannai	- 8 individuals
Massilina sp.	- 3 "
Phylum ARTHROPODA	
Class Crustacea	
ostracods	
Pseudophilomedes sp.	- 3 individuals
Phylum MOLLUSCA	
Class Bivalvia	
Nuculana sp. juv.	- 1 individuals
Modiolus sp. juv.	- 1 "
Spisula cf. *S. catilliformis*	- 4 "
Mysella tumida	- 6 "
Macoma sp.	- 1 "
Tellina bodegensis	- 7 "
"WORMS"	
chitinous worm tubes	- few
Phylum VERTEBRATA	
vertebrae	- 2 individuals

Sample 1639

Total sample weight: 627 grams

Percentage of organic hard parts in sample: 0.5%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 7 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

two genera

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 1 individuals
Mutilus (Aurila) sp.	- 1 "
barnacles	
Balanus sp.	- 1 "
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Amphineura

Mopalia sp.	- 1 individuals

Class Bivalvia

Nuculana sp.	- 1 individuals
Clinocardium nuttallii	- 1 "
Transennella tantilla	- 3 "
Spisula cf. S. catilliformis	- 9 "
Mysella tumida	- 10 "
Mysella sp.	- 1 "
Tellina salmonea	- 3 "
Tellina bodegensis	- 11 "

Class Gastropoda

Olivella sp.	- 2 individuals
Mitrella sp.	- 1 "

Sample 1639 cont.

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus - 1 individuals

Sample 1640

Total sample weight: 973 grams

Percentage of organic hard parts in sample: 0.7%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 4 individuals
Tricohyalus sp.	- 10 "

Phylum BRYOZOA (Entoprocta and Ectoprocta)

three genera

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 6 individuals

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 3 individuals
Hinnites multirugosus	- 1 "
Siliqua sp.	- 1 "
Clinocardium nuttallii	- 1 "
Transennella tantilla	- 2 "
Mysella tumida	- 3 "
Mysella sp.	- 1 "
Tellina salmonea	- 9 "
Tellina bodegensis	- 2 "

Class Gastropoda

Homalopoma sp.	- 1 individuals
Olivella baetica	- 5 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Phylum VERTEBRATA

skate tooth	- one specimen

Sample 1641

Total sample weight: 1803 grams

Percentage of organic hard parts in sample: 0.1%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 2 individuals

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 5 individuals

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 1 individuals
Protothaca sp.	- 1 "
Spisula cf. S. catilliformis	- 4 "
Transennella tantilla	- 1 "
Macoma sp.	- 2 "
Tellina salmonea	- 4 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 2 individuals

Sample 1642

Total sample weight: 1570 grams

Percentage of organic hard parts in sample: 0.1%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 2 individuals
Tricohyalus sp.	- 2 "

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 4 individuals

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 2 individuals
Protothaca staminea	- 1 "
Transennella tantilla	- 2 "
Mysella tumida	- 1 "
Tellina salmonea	- 1 "
Macoma sp.	- 1 "

Class Gastropoda

Crepidula sp. juv.	- 1 individuals
Olivella bactica	- 1 "

Sample 1643

Total sample weight: 2164 grams

Percentage of organic hard parts in sample: 0.04%

Phylum PROTISTA	
Order Foraminifera	
Elphidiella hannai	- 1 individuals
Tricohyalus sp.	- 1 "
Phylum ARTHROPODA	
Class Crustacea	
barnacles	
Balanus sp.	- 3 individuals
crabs	
Cancer sp.	- 2 "
Phylum MOLLUSCA	
Class Bivalvia	
Spisula cf. *S. catilliformis*	- 3 individuals
Siliqua sp.	- 1 "
Axinopsida sericata	- 1 "
Tellina salmonea	- 5 "
Class Gastropoda	
Nassarius sp.	- 1 individuals
Mitrella gouldii	- 2 "
Phylum ECHINODERMATA	
Class Echinoidea	
Dendraster excentricus	- 1 individuals

Sample 1644

Total sample weight: 850 grams

Percentage of organic hard parts in sample: 0.02%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 1 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 2 individuals

Phylum MOLLUSCA
Class Bivalvia

Transennella tantilla	- 1 individuals
Spisula cf. S. catilliformis	- 1 "
Mysella tumida	- 1 "
Tellina salmonea	- 1 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

"WORMS"

worm jaw	- one specimen

Phylum VERTEBRATA

vertebrae	- one specimen

Sample 1645

Total sample weight: 1545 grams

Percentage of organic hard parts in sample: 0.07%

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA

Class Crustacea

ostracods	
Pseudophilomedes sp.	- 1 individuals
barnacles	
Balanus sp.	- 3 "
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA

Class Bivalvia

Nuculana taphria	- 3 individuals
Modiolus sp. juv.	- 3 "
Chlamys sp. juv.	- 1 "
Spisula cf. S. catilliformis	- 3 "
Transennella tantilla	- 1 "
Mysella tumida	- 3 "
Mya sp.	- 1 "
Macoma sp.	- 2 "
Tellina salmonea	- 5 "
Tellina bodegensis	- 9 "

Class Gastropoda

Olivella baetica	- 3 individuals
Epitonium sp.	- 1 "

Phylum ECHINODERMATA

Class Echinoidea

Dendraster excentricus	- 2 individuals

Sample 1646

Total sample weight: 228 grams

Percentage of organic hard parts in sample: 1.4%

Phylum PROTISTA	
Order Foraminifera	
Elphidiella hannai	- 70 individuals
Phylum ARTHROPODA	
Class Crustacea	
ostracods	
Pseudophilomedes sp.	- 1 individuals
Phylum MOLLUSCA	
Class Bivalvia	
Nuculana sp.	- 1 individuals
Mysella tumida	- 10 "
Tellina bodegensis	- 4 "
"WORMS"	
chitinous worm tubes	- few

Sample 1647

Total sample weight: 288 grams

Percentage of organic hard parts in sample: 1.6%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 60 individuals

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 3 individuals
barnacles	
Balanus sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria juv.	- 2 individuals
Mysella tumida	- 27 "
Tellina bodegensis	- 12 "

Class Gastropoda

Nassarius sp.	- 1 individuals
Acteocina sp. juv.	- 1 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

"WORMS"

chitinous worm tubes	- abundant

Sample 1648

Total sample weight: 842 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 2 individuals

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 1 individuals
barnacles	
Balanus sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 1 individuals
Protothaca staminea	- 1 "
Siliqua sp.	- 1 "
Mysella tumida	- 6 "
Tellina bodegensis	- 4 "

Class Scaphopoda

Cadulus fusiformis	- 1 individuals

"WORMS"

chitinous worm tubes	- few

Phylum VERTEBRATA

vertebrae	- one specimen

Sample 1649

Total sample weight: 2137 grams

Percentage of organic hard parts in sample: 0.05%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 2 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 2 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 2 individuals
Siliqua sp.	- 1 "
Spisula cf. S. catilliformis	- 7 "
Mysella sp.	- 1 "
Tellina salmonea	- 6 "
Tellina bodegensis	- 1 "

Class Gastropoda

Olivella baetica	- 1 individuals
Odostomia sp.	- 1 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1650

Total sample weight: 2306 grams

Percentage of organic hard parts in sample: 0.1%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 1 individuals
Tricohyalus sp.	- 1 "

Phylum BRYOZOA (Entoprocta and Ectoprocta)

four genera

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 3 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 2 individuals
Spisula cf. S. catilliformis	- 4 "
Siliqua sp.	- 1 "
Clinocardium nuttallii	- 1 "
Mysella tumida	- 1 "
Macoma sp.	- 2 "
Tellina bodegensis	- 2 "

Class Gastropoda

Crepidula sp. juv.	- 3 individuals
Olivella baetica	- 3 "
Micranellum ? sp.	- 1 "

"WORMS"

chitinous worm tubes	- few

Sample 1652

Total sample weight: 1561 grams

Percentage of organic hard parts in sample: 0.4%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 2 individuals
Tricohyalus sp.	- 1 "

Phylum BRYOZOA (Entoprocta and Ectoprocta)

three genera

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 40 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 1 individuals
Siliqua patula	- 1 "
Spisula cf. _S. catilliformis_	- 6 "
Transennella tantilla	- 2 "
Macoma sp.	- 1 "
Tellina salmonea	- 27 "
Tellina bodegensis	- 3 "

Class Gastropoda

Olivella baetica	- 2 individuals

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Phylum VERTEBRATA

vertebrae	- one specimen

Sample 1653

Total sample weight: 965 grams

Percentage of organic hard parts in sample: 0.4%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 1 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

two genera

Phylum ARTHROPODA
Class Crustacea

barnacles

Balanus sp.	- 1 individuals

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 3 individuals
Chlamys sp.	- 1 "
Spisula cf. S. catilliformis	- 1 "
Siliqua sp.	- 1 "
Tellina salmonea	- 3 "
Tellina bodegensis	- 1 "

Class Gastropoda

Olivella sp.	- 1 individuals

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1654

Total sample weight: 831 grams

Percentage of organic hard parts in sample: 0.6%

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 3 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana sp.	- 1 individuals
Clinocardium nuttallii	- 1 "
Siliqua sp.	- 1 "
Spisula cf. S. catilliformis	- 1 "
Tellina salmonea	- 2 "
Tellina bodegensis	- 1 "

Class Gastropoda

Crepidula sp. juv.	- 1 individuals
Nassarius perpinguis	- 2 "
Olivella sp.	- 3 "
Micranellum ? sp.	- 1 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1655

Total sample weight: 1681 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 1 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

two genera

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 1 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Ostrea lurida	- 1 individuals
Clinocardium nuttallii	- 1 "
Spisula cf. S. catilliformis	- 4 "
Siliqua sp.	- 1 "
Kellia laperousii	- 1 "
Mysella tumida	- 2 "
Tellina salmonea	- 3 "

Class Gastropoda

Olivella baetica	- 8 individuals

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

"WORMS"

chitinous worm tubes	- few

Sample 1656

Total sample weight: 1270 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 1 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

two genera

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 1 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 3 individuals
Clinocardium nuttallii	- 1 "
Spisula cf. S. catilliformis	- 4 "
Macoma sp.	- 1 "
Tellina salmonea	- 3 "
Tellina bodegensis	- 2 "

Class Gastropoda

Nassarius perpinguis	- 1 individuals
Olivella baetica	- 4 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1657

Total sample weight: 220 grams

Percentage of organic hard parts in sample: 0.5%

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA
Class Crustacea

barnacles	
<u>Balanus</u> sp.	- 1 individuals
crabs	
<u>Cancer</u> sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

<u>Macoma</u> sp.	- 1 individuals
<u>Tellina</u> <u>salmonea</u>	- 2 "

Class Gastropoda

<u>Olivella</u> <u>baetica</u>	- 1 individuals

Phylum ECHINODERMATA
Class Echinoidea

<u>Dendraster</u> <u>excentricus</u>	- 1 individuals

Sample 1658

Total sample weight: 1329 grams

Percentage of organic hard parts in sample: 0.3%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 2 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

two genera

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 3 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 1 individuals
Siliqua sp.	- 1 "
Spisula cf. S. catilliformis	- 4 "
Transennella tantilla	- 1 "
Tellina salmonea	- 9 "
Tellina bodegensis	- 2 "

Class Gastropoda

Nassarius sp.	- 1 individuals
Olivella baetica	- 3 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1659

Total sample weight: 1363 grams

Percentage of organic hard parts in sample: 0.04%

Phylum PROTISTA
Order Foraminifera

Tricohyalus sp.	- 1 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

two genera

Phylum ARTHROPODA
Class Crustacea

barnacles

Balanus sp.	- 1 individuals

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 1 individuals
Clinocardium nuttallii	- 1 "
Spisula cf. S. catilliformis	- 2 "
Tellina salmonea	- 5 "

Class Gastropoda

Olivella sp.	- 1 individuals
Mitrella sp.	- 1 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

"WORMS"

chitinous worm tubes	- few

Sample 1660

Total sample weight: 845 grams

Percentage of organic hard parts in sample: 0.3%

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 1 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 1 individuals
Chlamys sp. juv.	- 1 "
Tellina salmonea	- 8 "

Class Gastropoda

Olivella baetica	- 1 individuals

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1661

Total sample weight: 1385 grams

Percentage of organic hard parts in sample: 0.1%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai - 1 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

two genera

Phylum ARTHROPODA
Class Crustacea

barnacles
Balanus sp. - 2 individuals

Phylum MOLLUSCA
Class Bivalvia

Modiolus sp. juv.	- 1 individuals
Spisula cf. S. catilliformis	- 1 "
Mysella tumida	- 1 "
Tellina salmonea	- 13 "

Class Gastropoda

Olivella baetica - 2 individuals

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus - 1 individuals

"WORMS"

chitinous worm tubes - few

Sample 1662

Total sample weight: 1065 grams

Percentage of organic hard parts in sample: 0.3%

Phylum ARTHROPODA	
Class Crustacea	
barnacles	
Balanus sp.	- 2 individuals
crabs	
Cancer sp.	- 1 "
Phylum MOLLUSCA	
Class Bivalvia	
Modiolus sp. juv.	- 1 individuals
Spisula cf. *S. catilliformis*	- 1 "
Macoma secta ?	- 1 "
Macoma sp.	- 1 "
Tellina salmonea	- 11 "
Tellina bodegensis	- 1 "
Class Gastropoda	
Olivella baetica	- 2 individuals
Phylum ECHINODERMATA	
Class Echinoidea	
Dendraster excentricus	- 1 individuals

Sample 1663

Total sample weight: 1783 grams

Percentage of organic hard parts in sample: 0.6%

Phylum ARTHROPODA
Class Crustacea

barnacles

Balanus sp.	- 3 individuals

Phylum MOLLUSCA
Class Bivalvia

Ostrea lurida	- 1 individuals
Spisula cf. *S. catilliformis*	- 3 "
Clinocardium nuttallii	- 1 "
Macoma sp.	- 1 "
Tellina salmonea	- 10 "

Class Gastropoda

Nassarius sp.	- 1 individuals
Olivella baetica	- 7 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 2 individuals

Sample 1664

Total sample weight: 1618 grams

Percentage of organic hard parts in sample: 0.4%

Phylum ARTHROPODA
Class Crustacea

barnacles

Balanus sp.	- 2 individuals

Phylum MOLLUSCA
Class Bivalvia

Spisula cf. S. catilliformis	- 5 individuals
Mysella tumida	- 3 "
Tellina salmonea	- 8 "
Tellina bodegensis	- 3 "

Class Gastropoda

Nassarius perpinguis	- 2 individuals
Olivella baetica	- 5 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1665

Total sample weight: 926 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 25 individuals
Tricohyalus sp.	- 2 "

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA
Class Crustacea

ostracods

Pseudophilomedes sp.	- 1 individuals

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 7 individuals
Clinocardium nuttallii	- 1 "
Spisula cf. S. catilliformis	- 3 "
Siliqua patula	- 3 "
Mysella tumida	- 5 "
Macoma sp.	- 2 "
Tellina bodegensis	- 15 "
Nettastomella sp.	- 1 "

Class Gastropoda

Nassarius perpinguis	- 2 individuals

"WORMS"

chitinous worm tubes	- abundant

Sample 1666

Total sample weight: 776 grams

Percentage of organic hard parts in sample: 0.06%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 6 individuals

Phylum BRYOZOA (Entoprocta and Ectoprocta)

one genus

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 2 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 4 individuals
Pandora bilirata ?	- 1 "
Clinocardium nuttallii	- 2 "
Mysella tumida	- 2 "
Spisula cf. S. catilliformis	- 40 "
Macoma sp.	- 3 "
Tellina salmonea	- 1 "
Tellina bodegensis	- 8 "

Class Gastropoda

Olivella sp.	- 2 individuals
Acteon? sp.	- 1 "

"WORMS

chitinous worm tubes	- few

Phylum VERTEBRATA

vertebrae	- two specimens

Sample 1667

Total sample weight: 2748 grams

Percentage of organic hard parts in sample: 0.1%

Phylum ARTHROPODA
Class Crustacea

barnacles

Balanus sp.	- 3 individuals

Phylum MOLLUSCA
Class Bivalvia

Spisula cf. S. catilliformis	- 1 individuals

Class Gastropoda

Acmaea sp. juv.	- 1 individuals
Olivella baetica	- 12 "

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

Sample 1668

Total sample weight: 1026 grams

Percentage of organic hard parts in sample: 0.05%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 1 individuals

Phylum ARTHROPODA
Class Crustacea

barnacles	
Balanus sp.	- 1 individuals

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 1 individuals
Pandora bilirata	- 1 "
Protothaca staminea	- 2 "
Siliqua sp.	- 1 "
Spisula cf. *S. catilliformis*	- 9 "
Tellina bodegensis	- 3 "

Class Gastropoda

Olivella sp.	- 1 individuals

Phylum ECHINODERMATA
Class Echinoidea

Dendraster excentricus	- 1 individuals

"WORMS"

chitinous worm tubes	- few

Sample 1669

Total sample weight: 1431 grams

Percentage of organic hard parts in sample: 0.2%

Phylum ARTHROPODA	
Class Crustacea	
ostracods	
Pseudophilomedes sp.	- 1 individuals
barancles	
Balanus sp.	- 3 "
Phylum MOLLUSCA	
Class Bivalvia	
Nuculana sp.	- 1 individuals
Protothaca staminea	- 1 "
Clinocardium nuttallii	- 1 "
Siliqua sp.	- 1 "
Mysella tumida	- 1 "
Spisula cf. _S. catilliformis_	- 9 "
Macoma sp.	- 2 "
Tellina bodegensis	- 9 "
Class Gastropoda	
Olivella baetica	- 1 individuals
Mangelia barbarensis	- 1 "
Acteon? sp.	- 1 "
"WORMS"	
chitinous worm tubes	- few
Phylum VERTEBRATA	
vertebrae	- one specimen

Sample 1670

Total sample weight: 793 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 25 individuals

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 1 individuals
barnacles	
Balanus sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 4 individuals
Yoldia ? sp.	- 1 "
Protothaca staminea	- 8 "
Cooperella ? sp.	- 1 "
Spisula cf. S. catilliformis	- 1 "
Mysella tumida	- 6 "
Macoma sp.	- 1 "
Tellina bodegensis	- 3 "

Class Gastropoda

Nassarius sp.	- 1 individuals
Odostomia sp.	- 4 "

"WORMS"

chitinous worm tubes	- few

Sample 1671

Total sample weight: 1743 grams

Percentage of organic hard parts in sample: 0.3%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 75 individuals

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 9 individuals
barnacles	
Balanus sp.	- 3 "
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 11 individuals
Pandora bilirata	- 6 "
Protothaca staminea	- 13 "
Clinocardium nuttallii	- 1 "
Mysella tumida	- 16 "
Spisula cf. S. catilliformis	- 6 "
Axinopsida sericata	- 3 "
Siliqua sp.	- 1 "
Macoma sp.	- 3 "
Tellina bodegensis	- 28 "

Class Scaphopoda

Cadulus sp.	- 1 individuals

Class Gastropoda

Nassarius perpinguis	- 2 individuals
Mitrella gouldii	- 1 "
Mangelia barbarensis	- 1 "
Odostomia sp.	- 3 "

"WORMS"

chitinous worm tubes	- abundant

Sample 1673

Total sample weight: 583 grams

Percentage of organic hard parts in sample: 0.1%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 35 individuals
Massilina sp.	- 1 "

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 2 individuals
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 7 individuals
Protothaca staminea	- 1 "
Clinocardium nuttallii	- 1 "
Mysella tumida	- 7 "
Solen sp.	- 1 "
Spisula cf. *S. catilliformis*	- 1 "
Macoma sp.	- 1 "
Axinopsida sericata	- 1 "
Tellina bodegensis	- 18 "

Class Gastropoda

Mitrella gouldii	- 1 individuals
Odostomia sp.	- 1 "

"WORMS"

chitinous worm tubes	- few

Sample 1674

Total sample weight: 308 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 30 individuals

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 7 individuals
barnacles	
Balanus sp.	- 2 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 3 individuals
Protothaca staminea	- 5 "
Mysella tumida	- 7 "
Spisula cf. S. catilliformis	- 1 "
Axinopsida sericata	- 1 "
Tellina bodegensis	- 12 "

"WORMS"

chitinous worm tubes	- few

Sample 1675

Total sample weight: 1173 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 70 individuals

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 8 individuals

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 8 individuals
Protothaca staminea	- 3 "
Siliqua sp.	- 1 "
Mysella tumida	- 11 "
Axinopsida sericata	- 4 "
Macoma sp.	- 2 "
Tellina bodegensis	- 11 "

Class Scaphopoda

Cadulus sp.	- 1 individuals

Class Gastropoda

Olivella baetica	- 1 individuals
Mitrella gouldii	- 1 "
Mangelia barbarensis	- 1 "
Odostomia sp.	- 1 "
Acteon ? sp.	- 1 "

"WORMS"

chitinous worm tubes	- few
agglutinated worm tubes	- few

Sample 1676

Total sample weight: 1404 grams

Percentage of organic hard parts in sample: 0.2%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 120 individuals
Nonionella sp.	- 5 "

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 40 individuals
barnacles	
Balanus sp.	- 2 "
crabs	
Cancer sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 24 individuals
Modiolus sp. juv.	- 1 "
Siliqua sp.	- 6 "
Solen sp.	- 1 "
Mysella tumida	- 105 "
Cooperella subdiaphana	- 1 "
Spisula cf. S. catilliformis	- 1 "
Axinopsida sericata	- 1 "
Macoma sp.	- 9 "
Tellina bodegensis	- 12 "

Class Scaphopoda

Cadulus sp.	- 1 individuals

Class Gastropoda

Nassarius perpinguis	- 2 individuals
Mitrella gouldii	- 13 "
Mangelia barbarensis	- 1 "
Odostomia sp.	- 4 "
Turbonilla sp.	- 2 "

Sample 1676 cont.

"WORMS"

chitinous worm tubes	- abundant
agglutinated worm tubes	- few

Sample 1677

Total sample weight: 511 grams

Percentage of organic hard parts in sample: 0.1%

Phylum PROTISTA
Order Foraminifera

Elphidiella hannai	- 35 individuals
Massilina sp.	- 1 "
Nonionella sp.	- 1 "

Phylum ARTHROPODA
Class Crustacea

ostracods	
Pseudophilomedes sp.	- 17 individuals
barnacles	
Balanus sp.	- 1 "

Phylum MOLLUSCA
Class Bivalvia

Nuculana taphria	- 3 individuals
Siliqua patula	- 5 "
Solen sp.	- 1 "
Mysella tumida	- 27 "
Axinopsida sericata	- 1 "
Macoma sp.	- 4 "
Tellina bodegensis	- 1 "

Class Gastropoda

Mitrella gouldii	- 1 individuals
Mangelia barbarensis	- 1 "

"WORMS"

chitinous worm tubes	- abundant

Phylum VERTEBRATA

vertebrae	- one specimen

April, 1970

BENTHIC ANALYSIS

STATION 3 DATE 4/22/70 COLLECTED BY Brown & Caldwell LAB NO. 1

CAPTURE METHOD PETERSON GRAB DEPTH 100' SUBSTRATE CLAY-SAND ANALYZED BY BIRKE

VOLUME SAMPLED (ml) 500 ALIQUOT (ml) TOTAL NO. SPECIES 1 NUMBER OF ORGANISMS/l 4

DIVERSITY INDEX PREDOMINANT ORGANISMS POLYCHAETES

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
POLYCHAETE	2			

BENTHIC ANALYSIS

STATION 5 DATE 4/22/70 COLLECTED BY Brown & Caldwell LAB NO. 2

CAPTURE METHOD PETERSON GRAB DEPTH 80' SUBSTRATE SAND ANALYZED BY BIRKE

VOLUME SAMPLED (ml) 500 ALIQUOT (ml) TOTAL NO. SPECIES 5 NUMBER OF ORGANISMS/l 14

DIVERSITY INDEX PREDOMINANT ORGANISMS

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
AMPHIPOD	1			
ANNELID	2			
TUBE WORM	1			
OLIVELLA SP.	2			
WHELK	1			

June, 1970

BENTHIC ANALYSIS

STATION 4 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 3

CAPTURE METHOD PETERSON GRAB DEPTH 60' SUBSTRATE CLAY-MUD ANALYZED BY L. Birke

VOLUME SAMPLED (ml) 1,000 ALIQUOT (ml) TOTAL NO. SPECIES 1 NUMBER OF ORGANISMS/l 1

DIVERSITY INDEX PREDOMINANT ORGANISMS PHORONID

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PHORONID	1			
SNAIL SHELLS				
SHELL FRAGMENTS				

BENTHIC ANALYSIS

STATION	8	DATE	6/19/70	COLLECTED BY	Brown Caldwell	LAB NO.	4
CAPTURE METHOD	PETERSON GRAB	DEPTH	60'	SUBSTRATE	SAND-CLAY	ANALYZED BY	L. Birke
VOLUME SAMPLED (ml)	500	ALIQUOT (ml)	TOTAL	NO. SPECIES	0	NUMBER OF ORGANISMS/l	0
DIVERSITY INDEX		PREDOMINANT ORGANISMS					

IDENTIFICATION	NO.ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
SHELL FRAGMENTS ONLY				

BENTHIC ANALYSIS

STATION 6 DATE 6/19/70 COLLECTED BY Brown & Caldwell LAB NO. 5

CAPTURE METHOD PETERSON GRAB DEPTH 55' SUBSTRATE Sand - Clay ANALYZED BY L. Birke

VOLUME SAMPLED (ml) 500 ALIQUOT (ml) TOTAL NO. SPECIES NUMBER OF ORGANISMS/l 222

DIVERSITY INDEX PREDOMINANT ORGANISMS

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
NEMERTEA	45			
NEMATODES	25			
ANNELIDA	22			
HEMICHORDATE	19			
	111			

October, 1970

BENTHIC ANALYSIS

STATION 7 DATE October 5, 1970 COLLECTED BY Brown & Caldwell LAB NO. 6 (1 of 2)

CAPTURE METHOD PETERSON GRAB DEPTH 35' SUBSTRATE SAND ANALYZED BY Glimme

VOLUME SAMPLED (ml) 780 ALIQUOT (ml) TOTAL NO. SPECIES 28 NUMBER OF ORGANISMS/l

DIVERSITY INDEX 7.50 PREDOMINANT ORGANISMS POLYCHAETA

DENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
OLIGOCHAETA				
Sp 1	38			
Sp 2	68			
Sp 3	30			
Sp 4	18			
POLYCHAETA ERRANTIA				
Eteone	900			
Glycera	8			
Nereis	84			
Sp 1	15			
Sp 2	10			
ANACHNIDA				
Hydracarina	1			
CRUSTACEA				
Amphipoda				
Gammarus	17			
Cirripedia				
Balanus	3			
Copepoda				
Calanoid	4			
Cyclopoid	1			
CUMACEA	10			
ANTHOZOA	1			
BRYOZOA				
Chellostome	3			
Cyclostome	1			
HYDROZOA	1			
GASTROPODA				
Olivella	23			
PELECYPODA				
Tellina	40			
Tellina	6			

BENTHIC ANALYSIS

STATION ______ DATE ______ COLLECTED BY ______ LAB NO. 6

(2 of 2)

CAPTURE METHOD ______ DEPTH ______ SUBSTRATE ______ ANALYZED BY ______

VOLUME SAMPLED (ml) ______ ALIQUOT (ml) ______ NO. SPECIES ______ NUMBER OF ORGANISMS/l ______

DIVERSITY INDEX ______ PREDOMINANT ORGANISMS ______

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
NEMATODA				
Sp 1	30			
Sp 2	430			
NEMERTEANS				
Sp 1	1			
Sp 2	36			
TURBELLARIA				
Sp 1	32			
Sp 2	1			
	1,812			

BENTHIC ANALYSIS

STATION 7 DATE October 5, 1970 COLLECTED BY Brown & Caldwell LAB NO. 7

(1 of 2)

CAPTURE METHOD PETERSON GRAB DEPTH 35' SUBSTRATE SAND ANALYZED BY Glirme

VOLUME SAMPLED (ml) 750 ALIQUOT (ml) TOTAL NO. SPECIES 29 NUMBER OF ORGANISMS/l

DIVERSITY INDEX 5.06 PREDOMINANT ORGANISMS POLYCHAETES

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
OLIGOCHAETA				
Sp 1	1			
Sp 2	5			
POLYCHAETA				
Eteone	150			
Glycera	2			
Glycinde	22			
Goniadid	3			
Haploscoloplos	1			
Lumbrinareid	2			
Nepthys	1			
Nothria	1			
Owenia	6			
Pectinaria	3			
Sabellida	1			
Magelonid	1			
ANACHNIDA				
Sp 1	1			
Sp 2	1			
CRUSTACEA				
Cumacea	2			
COELENTERATA				
Bryozoa	2			
Hydrozoa				
Sp 1	1			
Sp 2	1			
Sp 3	1			
GASTROPODA				
Nassarius	2			
NUDIBRANCHIA				
Eolid	1			
PELECYPODA				
Tellina	17			

BENTHIC ANALYSIS

STATION ______ DATE ______ COLLECTED BY ______ LAB NO. 7 (2 of 2)

CAPTURE METHOD ______ DEPTH ______ SUBSTRATE ______ ANALYZED BY ______

VOLUME SAMPLED (ml) ______ ALIQUOT (ml) ______ NO. SPECIES ______ NUMBER OF ORGANISMS/l ______

DIVERSITY INDEX ______ PREDOMINANT ORGANISMS ______

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
NEMERTEANS				
Sp 1	2			
Sp 2	5			
SIPUNCULIDS				
Sp 1	3			
TURBELLARIANS				
Sp 1	1			
Sp 2	12			
	251			

BENTHIC ANALYSIS

STATION 9 DATE October 5, 1970 COLLECTED BY Brown & Caldwell LAB NO. 8

CAPTURE METHOD PETERSON GRAB DEPTH 60' SUBSTRATE FINE SAND ANALYZED BY Bailey

VOLUME SAMPLED (ml) 780 ALIQUOT (ml) TOTAL NO. SPECIES 19 plus pieces of unknown tube worm NUMBER OF ORGANISMS/l

DIVERSITY INDEX 4.27 PREDOMINANT ORGANISMS TUBE WORM D

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
PORIFERA	1			
POLICHAETE	1			
HYDROZOA COLONY	2			
POLYCHAETE G	1			
POLYCHAETE H	1			
NEMERTEAN	1			
PECTINARIDAE	7 + pieces			
TUBE WORM A	4			
TUBE WORM B	8			
TUBE WORM C	4			
TUBE WORM D	18			
TUBE WORM (Unknown)	8			
WORM X	2			
NEMATODA	1			
SILIQUA PATULA	2			
Clam B	1			
Clam C	2			
Clam D	2			
Clam E	2			
	68			

BENTHIC ANALYSIS

STATION 9 DATE October 5, 1970 COLLECTED BY Brown & Caldwell LAB NO. 9

CAPTURE METHOD PETERSON GRAB DEPTH 60' SUBSTRATE FINE SAND ANALYZED BY Glimme

VOLUME SAMPLED (ml) 760 ALIQUOT (ml) TOTAL NO. SPECIES 23 NUMBER OF ORGANISMS/l

DIVERSITY INDEX 5.70 PREDOMINANT ORGANISMS POLYCHAETA & CUMACEA

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M³		
POLYCHAETA				
Glycinde	18			
Haploscoloplos	1			
Hesperonoe	1			
Malandoe	1			
Magelona	3			
Neanthes	1			
Nepthys	3			
Nereid	1			
Nothria	5			
Pectinaria	3			
Owenia	53			
AMPHIPODA				
Sp 1	1			
Sp 2	7			
ISOPODA				
Sp 1	2			
CIRRIPEDIA				
Balanus cienatus	1			
CUMACEA				
Sp 1	87			
COELENTERATA				
Hydroid				
Thicate	1			
NEMATODA				
Sp 1	50			
GASTROPODA				
Nassarius	2			
PELECYPODA				
?	2			
Macoma	20			
Tapes	1			
Tellina	34			
	298			

BENTHIC ANALYSIS

STATION 2 DATE October 6, 1970 COLLECTED BY Brown & Caldwell LAB NO. 10

CAPTURE METHOD PETERSON GRAB DEPTH 55' - 80' SUBSTRATE SANDY BOTTOM ANALYZED BY Bailey

VOLUME SAMPLED (ml) 250 ALIQUOT (ml) 25 ml NO. SPECIES 11 NUMBER OF ORGANISMS/l

DIVERSITY INDEX 1.34 PREDOMINANT ORGANISMS POLYCHAETE & NEMATODES

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
PORIFERA	1			
YOUNG CUMACEA	1			
POLYCHAETE F	7			
NEMATODA	44			
POLYCHAETE A	72			
POLYCHAETE B	11			
POLYCHAETE C	12			
POLYCHAETE D	15			
POLYCHAETE E	8			
SPIONIDAE	5			
MOLLUSCA	3			
	179			

BENTHIC ANALYSIS

STATION 1 DATE October 6, 1970 COLLECTED BY Brown & Caldwell LAB NO. 11

CAPTURE METHOD PETERSON GRAB DEPTH 55' - 80' SUBSTRATE SANDY BOTTOM ANALYZED BY Bailey

VOLUME SAMPLED (ml) 250 ALIQUOT (ml) 25 ml NO. SPECIES 10 NUMBER OF ORGANISMS/l

DIVERSITY INDEX PREDOMINANT ORGANISMS NEMATODA

IDENTIFICATION	NO. ORGANISMS PER ALIQUOT	NO. ORGANISMS PER M^3		
POLYCHAETE A	3			
PROTOTHACA	1 shell valve			
UROSALPINX	1			
MYA	1			
+ SHELL & ROCK FRAGMENTS	7			
NEMATODA A	3			
NEMATODA B	1390			
POLYCHAETE B	10			
NEMERTEAN	90			
CUMACEAN	80			
POLYCHAETE C	30			
PELECYPODA	30			
	1,639			

Diving Studies

Prepared for Brown and Caldwell
by Marine Biological Consultants, Inc.

Reference: Fig. 5-29

DESCRIPTION OF THE STATIONS

Gashouse Cove

Gashouse Cove lies about three miles within San Francisco Bay from the Golden Gate. Construction works enclose a portion of the Bay here and shelter a marina and fueling facility. Numerous oily slicks were noted in the cove. Our study of the area was not exhaustive and was conducted while waiting for our vessel to depart. In spite of the somewhat superficial character of the study, we recovered 13 plant and 23 animal species (Table 1).

Sunset-Richmond Discharge

The area surveyed was primarily sedimentary bottom, ranging from very fine sand and silt in deeper zones to moderately course sand at depths shallower than about 15 feet. Solid substrate consisted of a few shells and cobbles in deep water, a wreck at 10 to 20 foot depths and rocky cliffs at the water surface. Although it was unusually calm the day of our study, this area is typically exposed to violent water movements from large swell and surf. Underwater visibility ranged from 10 to 20 feet off shore to one to three feet inshore. Unpleasant oily odors pervaded the air near shore. The survey recovered ten plant species and 102 animals (Table 2). Attached plants extended only to depths of about 10 feet.

Point Bonita

The survey area lay almost entirely within the lee of the Point Bonita headland. Bottom was primarily rock interspersed with sand aggregates in the rocky basins. Topography was quite uneven and ridges, pinnacles, crevices and other irregularities were common. Thin layers of fine silt covered most of the deeper surfaces. A substantial fraction of the deeper rocky surface did not support animal encrustations, perhaps because of siltation. Underwater visibility ranged from 5 to 15 feet. Attached plants occurred sparsely at depths of 15 to 20 feet, becoming dominant shallower than 10 feet. The area yielded 18 plants and 139 animal species (Table 3).

Muir Beach

An offshore spot dive at a 60 foot depth here revealed flat sandy bottom with no organisms apparent on the sand surface. To sample substrate similar to the other stations, we examined the sides of a small island that barely broke the surface, about 1000 feet offshore. Underwater slopes ranged from about 5° to almost vertical. Topography was very irregular. Deep crevices and small caves and tunnels penetrated the sides of the islet. The rock substrate disappeared beneath a fine sand bottom at a depth of about 40 feet. Plant life dominated to depths of about 15 feet and disappeared at about 25 feet. Recoveries totaled 24 plants and 175 animals (Table 4).

Plants and Animals Observed
near Sunset-Richmond Outfall on 8 October 1970

Species	Number	Remarks
ALGAE		
Alaria marginata	P	wreck intertidal area
Bossiella Orbigniana	P	
Corallina vancouveriensis	P	on wreck
Endocladia muricata	P	on wreck
Gigartina californica	P	
Laminaria Sinclairii	P	wreck intertidal area
Microcladia borealis	P	
Prionitis lanceolata	P	wreck intertidal area
Ulva expansa	P	on wreck
S-6		
S-7		
PORIFERA		
Porifera, unident.	P	wreck intertidal area
CNIDARIA		
Hydrozoa		
Aglaophenia sp	(C)	
Campanularia sp	(C)	
Eucopella sp (near *caliculata*)	(C)	
Hydroid, unident.	P (1)	on wreck
Anthozoa		
Anthopleura elegantissima	P	on wreck
A. *xanthogrammica*	P	
Metridium exilis	P	
Tealia crassicornis	P	wreck intertidal area
Anthozoan, unident.	(3)	3-5 mm diameter

Species	Number	Remarks
NEMERTEA		
Nemerteans, unident.	(29)	
BRYOZOA		
Bowerbankia sp ?	(1)	one colony
Bugula sp	(1)	one colony
Membranipora sp	(A)	on rocks
Schizoporella sp	(S)	on rocks
PHORONIDA		
Phoronis sp	P	wreck intertidal area
NEMATODA		
Nematodes, unident.	(35)	
ANNELIDA		
Polychaeta		
Anaitides williamsi	(214)	
Aphrodita sp	(1)	posterior fragment
Autolytus varius	(4)	
Capitella capitata	(4)	
Diopatra ornata	P	wreck intertidal area
D. splendididissima	P	
Eulalia aviculiseta	(2)	
Genetyllis castanea	(1)	
Glycera sp	(3)	
Nereidiform, unident.	(1)	juvenile
Nereidae, unident.	(1)	juvenile

Species	Number	Remarks
ANNELIDA (cont.)		
Polychaeta (cont.)		
Nereis grubei	(1)	
N. latescens	(10)	
Phyllochaetopterus prolifica	P	
Pista sp	P	
Pista pacifica	P	
Polynoidae, unident.	4	
Ramex californiensis	45	
Sabellidae, unident.	(1)	
Serpulidae, unident.	P	wreck intertidal area
Typosyllis spp	(3)	juveniles
Typosyllis aciculata	(9)	
SIPUNCULOIDEA		
Sipunculoidea, unident.	(1)	
ARTHROPODA		
Pycnogonida		
Ammothella sp	(3)	
Pycnogonum rickettsi	(1)	
Crustacea		
Cirripedia		
Balanus sp	P	wreck intertidal area
Balanus glandula	P (385)	wreck intertidal area
Pollicipes polymerus	P (14)	on wreck and in intertidal area
Malacostraca		
Chelifera		
Anatanais normani	(22)	
Leptochelia sp	(12)	

Species	Number	Remarks
ARTHROPODA (cont.)		
Malacostraca (cont.)		
Isopoda		
"*Dynamenella*"sp (near *benedicti*)	(4)	
Ianiropsis sp	(1)	
Idothea sp	(1)	juvenile
Munna sp	(3)	
Synidotea ritteri	(1)	
Amphipoda		
Caprella angusta	(39)	
C. *californica*	(1)	
C. *equilibra*		
C. *incisa*	(45)	
Metacaprella spp	(7)	
Tritella pilimana	(2)	
Amphipods, gammarid, unident.	(241)	
Caprellids, unident.	(105)	
Decapoda		
Blepharipoda occidentalis	P	cast shell only
Cancer antennarius	P	cast shell only
C. *gibbosulus*	(3)	
Pugettia gracilis	(1)	
Pagurid, unident.	P	
MOLLUSCA		
Amphineura		
Chaetopleura gemma	(1)	
Tonicella lineata	P	

Species	Number	Remarks
MOLLUSCA (cont.)		
Gastropoda		
Acmaea digitalis	P (1)	on wreck
A. pelta	P	on wreck
Lacuna carinata	(1)	
Olivella biplicata	P (3)	
Thais sp	P	on wreck
Opisthobranchia		
Nudibranch, aeolid, unident.	(2)	
Pelecypoda		
Chione sp	(1)	juvenile
Hiatella arctica	(1)	
Modiolus capax	(43)	1-4 mm, juvenile
M. rectus	(1)	
Mytilus californianus	(1)	
M. edulis	(1)	
Philobrya setosa	(1)	
Veneridae, unident.	(4)	juvenile
Cephalopoda		
Octopus sp	P	
ECHINODERMATA		
Asteroidea		
Leptasterias sp	P	
Leptasterias aequalis	(7)	
Pisaster ochraceous	P	in wreck area
Pycnopodia helianthoides	P	
Ophiuroidea		
Ophiothrix spiculata	(4)	
Ophiuroid, unident.		
Holothurioidea		
Leptosynapta albicans	P	

Species	Number	Remarks
CHORDATA		
Urochordata		
Amaroucium sp	P	on wreck
Amaroucium solidum	(P)	
Pycnoclavella stanleyi	P	
Vertebrata		
Citharichthys stigmaeus	P (1)	
Clinocottus sp	P (1)	in wreck
Cymatogaster aggregata	P	in wreck area
Embiotoca lateralis	P	in wreck area
Hexagrammos decagrammus	P	in wreck area
Hypsurus caryi	P	in wreck area
Sebastes flavidus	P	in wreck area
S. *mystinus*	P	in wreck area
flatfish, unident.	P	turbot?
Miscellaneous		
Polychaete tubes, unident.	P	

Key:
- (1) Parenthetical numbers indicate organisms found in sediment collections
- P Present, no estimate of numbers
- C Common, unevenly present throughout sample, and only occasionally numerous
- A Abundant, numerous, and evenly distributed throughout sample

Plants and Animals Observed
at Point Bonita on 8 October 1970

Species	Number	Remarks
PLANTS		
Alaria marginata	P	
Bossiella Gardneri	P	
Callophyllis pinnata	P	
Corallina vancouveriensis	P	
Cryptopleura lobulifera	P	
Gymnogongrus platyphyllus	P	
Hymenena flabelligera	P	
Iridaea flaccida	P	
Laminaria Andersonii	P	
L. *Sinclairii*	P	
Laurencia sp	P	
Lithothamnion sp	P	
Microcladia borealis	P	
Phyllospadix torreyi	P	
Polyneura latissima	P	
Prionitis Andersonii	P	
Ralfsia pacifica	P	
Rhodoptilum densum	P	
PROTOZOA		
Foraminifera		
Elphidiella sp	(P)	
Pulvinulina sp	(C)	
Quinqueloculina sp	(P)	

Species	Number	Remarks
PORIFERA		
Cliona sp	P	
Cliona celata	(P)	in shell fragments
Ficulina sp	P (4)	
Mycale sp A	P (2)	probably a new species
Rhabdodermella nuttingi	P	
Suberitidae, unident.	P (3)	
CNIDARIA		
Hydrozoa		
Aglaophenia sp	P (C)	
Corymorpha palma	P	
Eucopella sp	(C)	on algae
Plumularia sp	(P)	
Hydroid, unident.	P	
Anthozoa		
Anthopleura artemisia	P	
A. *xanthogrammica*	P	
Astrangia lajollaensis	P	
Balanophyllia elegans	P	
Corynactis californica	P	
Epiactis prolifera	P	
Metridium exilis	P	
Parazoanthus sp	P	
Anthozoan, unident.	(7)	on empty *Balanus*
PLATYHELMINTHES		
Platyhelminthes, unident.	(3)	

Species	Number	Remarks
NEMERTEA		
Nemerteans, unident.	(36)	
BRYOZOA		
Alcyonidium sp	(P)	on rock and algae thallus
Caulibugula ciliata	(P)	
Crisia maxima	(P)	
Filicrisia franciscana	(P)	at base of *Aglaophenia*
Flustrella corniculata	(C)	on *Bossiella*
Hippothoa hyalina	(C)	on algae, rock, and shell fragments
Membranipora sp	(C)	on rock and shell fragments
Scrupocellaria sp	(C)	
PHORONIDA		
Phoronis sp	P	
NEMATODA		
Nematodes, unident.	(15)	
ANNELIDA		
Anaitides sp	(4)	
Arctonoe vittata	(1)	commensal with *Diodora*
Armandia bioculata	(32)	
Diopatra sp	P	
Eudistylia sp	P	
Eulalia aviculiseta	(2)	
Flabelligeridae, unident.	(1)	fragment
Glycera sp	(3)	

Species	Number	Remarks
ANNELIDA (cont.)		
Laonice cirrata	(21)	
Maldanidae, unident.	(1)	
Nereidiform, unident.	(9)	juvenile
Odontosyllis sp	(2)	
Ophelia sp	(11)	
Ramex californiensis	(1)	
Sabellidae, unident.	P	
Serpulidae, unident.	P	
Typosyllis spp	(3)	juvenile
Typosyllis aciculata	(3)	
ARTHROPODA		
Pycnogonida		
Ammothella sp	(3)	
Anoplodactylus nodosus	(1)	
Crustacea		
Ostracoda		
Ostracods, unident.	(7)	2 species (5:2)
Cirripedia		
Balanus sp	P	
Balanus glandula	(A)	on rock, algae, and shell debris
B. *nubilis*	P	
Pollicipes polymerus	P	
Malacostraca		
Cumacea		
Cumella sp	(4)	
Chelifera		
Leptochelia sp	(30)	

Species	Number	Remarks
ARTHROPODA (cont.)		
Malacostraca (cont.)		
Isopoda		
Ianiropsis sp	(5)	
Ianiropsis analoga	(3)	
Jaeropsis dubia	(5)	
Janiralata occidentalis	(1)	
Munna sp	(1)	female
Synidotea sp	(1)	juvenile
Synidotea consolidata	(3)	
S. *ritteri*	(15)	
Amphipoda		
Caprella spp	(24)	juveniles, prob. C. *equilibra*
Caprella angusta	(33)	represents 25% aliquot
C. *californica*	(1)	represents 25% aliquot
C. *equilibra*	(13)	represents 25% aliquot
C. *incisa*	(22)	represents 25% aliquot
C. *verrucosa*	(53)	represents 25% aliquot
Metacaprella spp	(71)	represents 25% aliquot from entire sample
Tritella pilimana	(27)	represents 25% aliquot from entire sample
Amphipods, corophid and gammarid, unident.	(558)	25% count from entire sample
Caprellids, unident.	(135)	juvenile, 25% count from entire sample
Decapoda		
Cancer antennarius	P (2)	
Pachycheles rudis	(1)	
Pagurid, unident.	P (1)	juvenile

Species	Number	Remarks
MOLLUSCA		
Gastropoda		
Acmaea asmi	P	
A. digitalis	P	
A. pelta	P	
Alvinia compacta	(7)	
Barleeia sp	(8)	1-2 mm
Buccinidae, unident.	(1)	juvenile, 3 mm
Calliostoma sp	(1)	juvenile, 5 mm
Calliostoma annulatum	P	
C. costatum	(1)	
Crepipatella lingulata	(1)	
Diodora aspera	(1)	
Haliotis rufescens	P	
Lacuna unifasciata	(5)	
Odostomia sp ?	(6)	juvenile, 1-2 mm
Thais sp	P	
Trochidae, unident.	(1)	juvenile, 1 mm
Turridae, unident.	(1)	juvenile, 2 mm
Opisthobranchia		
Archidoris sp	P	
Cadlina luteomarginata	P	
Diaulula sandiegensis	P	
Hermissenda crassicornis	P	
Triopha sp	P	
Pelecypoda		
Hiatella arctica	(1)	
Hinnites multirugosus	P	

Species	Number	Remarks
MOLLUSCA (cont.)		
Pelecypoda (cont.)		
Mytilus edulis	(4)	1-7 mm
M. *californianus*	P	
Pododesmus cepio	P	
Protothaca sp	(8)	juveniles, 1-3 mm
Volsella sp	(4)	juveniles, 1-2 mm
Veneridae, unident.	(1)	juvenile, 2 mm
Pelecypods, unident.	(6)	juveniles, 1-2 mm
ECHINODERMATA		
Asteroidea		
Dermasterias imbricata	P	
Henricia leviuscula	P	
Patiria miniata	P	
Pisaster brevispinus	P (1)	
P. *giganteus*	P	
P. *ochraceous*	P	
Pycnopodia helianthoides	P	
Ophiuroidea		
Amphiodia sp	(1)	
Ophiacantha sp	(1)	
CHORDATA		
Urochordata		
Amaroucium californicum	(2)	2 colonies, about 24 individuals

Species	Number	Remarks
CHORDATA (cont.)		
Vertebrata		
Atherinops sp	P	
Clinocottus sp	P	
Embiotoca lateralis	P	
Heterostichus rostratus	P	
Hexagrammos decagrammus	P	
Ophiodon elongatus	P	
Paralichthys californicus	P	
Platichthys stellatus	P	
Rathbunella sp ?	P	
Sebastes chrysomelas	P	
S. *flavidus*	P	
S. *mystinus*	P	
S. *serranoides*	P	
Scorpaena guttata	P	
Scorpaenichthys marmoratus	P	
Triakis semifasciata	P	

Key: (1) Parenthetical numbers indicate organisms found in sediment collections

P Present, no estimate of numbers

C Common, unevenly present throughout sample, and only occasionally numerous

A Abundant, numerous, evenly distributed throughout sample

Plants and Animals Recorded Along the Tennesse Cove - Muir Beach Transect on October 8, 1970

Species	Number	Remarks
PLANTS		
Bossiella Gardneri	P	
Botryoglossum farlowianum	P	
Calliarthron Setchelliae	P	
Callophyllis megalocarpa	P	
C. obtusifolia	P	
C. pinnata	P	
Gigartina californica	P	
Gymnogongrus platyphyllus	P	
Hymenena flabelligera	P	
Laminaria Andersonii	P	
L. Sinclairii	P	
Lithothamnion sp	P	
Microcladia borealis	P	
Polyneura latissima	P	
Polysiphonia Brodiaei	P	
Prionitis Andersonii	P	
Pterogophora californica	P	
Ptilota densa	P	
Rhodoglossum sp	P	
Rhodomela larix	P	
Rhodoptilum desum	P	
Rhodymenia pacifica	P	
S-2	P	
S-8	P	

Species	Number	Remarks
PROTOZOA		
Elphidiella sp	P (1)	
Discorbis sp	P	
Gromia oviformis	(34)	
"*Gromia*" like	(5)	large, 2-3mm dia.
Pulvinulina sp	P	
Vorticellid, unident.	P	on *Garvia*
PORIFERA		
Cliona sp	P	
C. celata	1	
Desmacidonidae (family), unident.	1	
Ficulina sp	1	probably new species
Haliclona sp	P	
H. lunisimilis	1	
Halichondria panicea	2	
Mycale macginitiei	2	
Mycale sp A.	1	probably new species
Mycale sp B.	1	probably new species
Myxilla agennes	1	
M. parasitica	1	
Polymastia pachymastia	P	
Rhabdodermella nuttingi	P	
CNIDARIA		
Hydrozoa		
Abietinaria spp	P	
Aglaophenia sp	P	
Campanularia sp	C	on *Aglaophenia* and rocks

Species	Number	Remarks
CNIDARIA (Cont.)		
Hydrozoa		
Campanularidae (family)	P	on rocks and shells
Eucopella sp (near *caliculata*)	P	on algal frag.
Garveia annulata	P	one colony
Plumularia sp	P	on rock
Sertularia sp	P	
Anthozoa		
Anthopleura artemisia	P	
A. *elegantissima*	P	
Corynactis californica	P	
Epiactis prolifera	P	
Metridium exilis	P	
Tealia crassicornis	P	
PLATYHELMINTHES		
Platyhelminthes, unident.	15	
NEMERTEA		
Nemertean, unident.	35	two species
BRYOZOA		
Alcyonidium sp	P	
Caulibugula sp	P	with *Scrupocellaria*
Crisia maxima	P	
Diaperoecia californica	P	
Flustrella corniculata	C	
Hippothoa hylina	C	
Scrupocellaria sp	P	
Tubiporidae (family), unident.	P	

Species	Number	Remarks
NEMATODA		
Nematodes, unident.	C	
ANNELIDA		
Anaitides sp	2	
Armandia bioculata	1	
Cirratulus cirratus	1	
Diopatra sp	P	
Dodecaceria fewkesi	16 (11)	
D. *fistulicola*	P	
Eteone sp ?	1	
Eudistylia sp	P	
Eulalia aviculiseta	5	
Flabelligeridae (family), unident.	1	fragment
Genetyllis castanea	2	
Glycera sp	(15)	
Hirudinidae (family), unident.	4	
Lumbrineris zonata	10	
Maldanidae (family), unident.	1	
Naineris dentritica	1	
Nepthys sp	2	
Nereis grubei	4	
Nereis sp	5 (3)	juveniles, 3-5mm
Odontsyllis sp	2	
Phyllochaetopterus prolifica	P	
Polydora sp	1	
Polynoidae (family), unident.	1	
Ramex californiensis	3	
Sabellidae (family), unident.	1	juvenile, 3mm

Species	Number	Remarks
ANNELIDA (Cont.)		
Syllidae (family), unident.	(1)	juvenile
Typosyllis spp	(2)	juvenile
Typosyllis aciculata	23 (4)	
T. _alternata_	5	
SIPUNCULOIDEA		
Sipunculid, unident.	2	
ARTHROPODA		
Pycnogonida		
Ammothella sp	1	
Nymphon heterdenticulatum	1	
Phoxichilidium femoratum	1	
Pycnogonum stearnsi	1	
Ostracoda		
Ostracods, unident.	17 (2)	two species
Copepoda		
Copepods, cyclopoid, unident.	P	
Copepods, harpacticoid, unident.	P	
Cirripedia		
Balanus glandula	C	on debris
B. _nubilis_	P	
Cumacea		
Diastylopsis sp	(12)	
Isopoda		
Anatanais normani	3	
Leptochelia sp	1	
Edotea sublittoralis	2	

Species	Number	Remarks
Isopoda (cont.)		
Ianiropsis sp	3	
I. *analoga*	12	
Idarcturus hedgpethi	1	from 25% aliquot
Idothea stenops	1	
Idothea sp	7	from 25% aliquot
Jaeropsis dubia	4	
Janiropsis sp	1	
Munna sp	12	
Neastacilla sp	1	
Synidotea sp	10	
S. *consolidata*	5	
S. *ritteri*	20	
Caprellidae		
Caprella spp	24	juveniles, prob. C. *equilibra*
C. *angusta*	519	from 25% aliquot
C. *californica*	12	" " "
C. *equilibra*	10	" " "
C. *incisa*	236	" " "
C. *verrucosa*	111	" " "
Caprellidae, unident.	2000	" " "
Metacaprella anomata	160	
M. *ferra*	50	
M. sp (near *anomata*)	19	
M. spp	265	juveniles, from 25% aliquot
Tritella pilimana	72	from 25% aliquot
Tritella sp	1	
Amphipoda		
Amphipods, corophid and gammarid	7500	from 25% aliquot

Species	Number	Remaks
Decapoda		
Cancer antennarius	2	
Cancer sp	1	juvenile
Loxorhynchus crispatus	P	
Pachycheles rudis	8	
Pagurus beringanus	3	
Pugettia gracilis	3	
Pagurid, unident.	2	juveniles
MOLLUSCA		
Amphineura		
Tonicella lineata	P	
Gastropoda		
Amphissa columbiana	1	
A. *versicolor*	1	
Calliostoma canaliculatum	5	
Lacuna unifasiata	7 (24)	
Lacuna sp	2	juvenile
Mangelia sp	1	juvenile
Mitrella carinata	6	
Ocenebra interfossa	1	
O. *lurida*	3	
Olivella pycna	3	
Pteropurpura trialata	1	
Tricolia sp	3	
Opisthobranchiata		
Archidoris sp	3	
Cadlina luteomarginata	P	
Cadlina sp	1	
Flabellina iodinea	P	
Hermissenda crassicornis	P	
Nudibranch, aeolid, unident.	3	

Species	Number	Remarks
Pelecypoda		
Hiatella arctica	2	
Hinnites multirugosus	P	
Mytilus edulis	2	
Tellina modesta	(1)	
Volsella capax	3	juvenile
Veneridae (family), unident.	5 (25)	juvenile
ECHIODERMATA		
Dermasterias imbricata	P	
Henricia leviuscula	2	
Leptasterias hexactis	4	
Patiria miniata	P	
Pisaster brevispinus	P	
P. ochraceous	P	
Pycnopodia helianthoides	P	
Ampiodia sp	23	
Holothuroidea, unident.	1	juvenile
ASCIDIACEA		
Amaroucium solidum	P	
Amaroucium sp	P	
Distaplia occidentalis	P	
Polycitoridae, unident.	P	three species
Synoicum sp	P	
VERTEBRATA		
Clinocottus sp	P	
Embiotoca lateralis	P	
Genyonemus lineatus	P	

Species	Number	Remarks
VERTEBRATA (Cont.)		
Heterostichus rostratus	P	
Hexagrammos sp	P	
Ophiodon elongatus	P	
Sebastes flavidus	P	
S. *mystinus*	C	

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List of Plants and Animals Observed
near the Golden Gate Entrance on 8 October 1970

Numerals in parentheses following species name indicate station of origin as below:

A. Gashouse Cove
B. Richmond-Sunset Area
C. Point Bonita
D. Muir Beach

Scientific Name	Occurrence	Common Name
ALGAE		
Alaria marginata Postels and Ruprecht	(B,C)	brown alga
Antithamnion sp	(A)	red alga
Bossiella Gardeni Manza	(C,D)	coralline alga
B. Orbigniana (Decaisne) Manza	(B)	coralline alga
Botryoglossum farlowianum (J. G. Agardh) Detoni	(D)	red alga
Calliarthron Setchelliae Manza	(D)	coralline alga
Callophyllis megalocarpa Setchell and Swezy	(D)	red alga
C. obtusifolia J. G. Agardh	(D)	red alga
C. pinnata Setchell and Swezy	(C,D)	red alga
Ceratium Gardneri Kylin	(A)	red alga
Colpomenia bullosus (Saunders) Yamada	(A)	brown alga
Corallina vancouveriensis Yendo	(B,C)	coralline alga
Cryptopleura lobulifera (J. G. Agardh) Kylin	(A,C)	red alga
Endocladia muricata (Postels and Ruprecht) J. G. Agardh	(B)	red alga
Fusus distichus subsp endentatus	(A)	brown alga
Gigartina californica J. G. Agardh	(A,B,D)	red alga
Gymnogongrus platyphyllus Gardner	(C,D)	red alga
Hymenena flabelligera (J. G. Agardh) Kylin	(C,D)	red alga
Iridaea flaccida (Setchell & Gardner)	(C)	red alga
Laminaria Andersonii Eaton	(C,D)	brown alga
L. Sinclairii (Harvey) Farlow	(A,B,C,D)	brown alga

Scientific Name	Occurrence	Common Name
ALGAE (cont.)		
Laurencia sp	(C)	red alga
Lithothamnion sp	(C,D)	coralline alga
Microclaudia sp	(A)	red alga
Microclaudia borealis Ruprecht	(B,C,D)	red alga
Phyllospadix torreyi S. Watson	(C)	surf grass (flowering plant)
Polyneura lattissima (Harvey) Kylin	(A,C,D)	red alga
Polysiponia Brodiaei (Dillwyn) Greville	(A,D)	red alga
Prionitis Andersonii Eaton	(A,C,D)	red alga
P. *lanceolata* Harvey	(B)	red alga
Pterygophora californica Ruprecht	(D)	brown alga
Ptilota densa C. A. Agardh	(D)	red alga
Ralfsia pacifica Hollenberg	(C)	brown alga
Rhodoglossum sp	(D)	red alga
Rhodomela Larix (Turner) C. A. Agardh	(D)	red alga
Rhodoptilum densum (Smith) Dawson	(C,D)	red alga
Rhodymenia pacifica Kylin	(D)	
Ulva expansa (Setchell) Setchell and Gardner	(A,B)	green alga
Weeksia sp	(D)	red alga
PROTOZOA		
Discorbis sp	(D)	foraminifera
Elphidiella sp	(A,C,D)	foraminifera
Gromia oviformis Dujardin	(D)	foraminifera
"*Gromia*" like	(D)	foraminifera

Scientific Name	Occurrence	Common Name
PROTOZOA (cont.)		
Pulvinulina sp	(D)	foraminifera
Quinqueloculina sp	(C)	foraminifera
Vorticellid, unident.	(D)	ciliate protozoa
PORIFERA		
Cliona sp	(C,D)	sponge
Cliona celata Grant	(C,D)	sponge
Desmacidonidae (family), unident.	(D)	sponge
Ficulina sp	(C,D)	sponge
Haliclona lunisimilis de Laubenfels	(D)	sponge
Haliclona sp	(D)	sponge
Halichondria panicea (Pallas)	(D)	sponge
Mycale macginitiei de Laubenfels	(D)	sponge
Mycale sp A	(C,D)	sponge
Mycale sp B	(D)	sponge
Myxilla agennes de Laubenfels	(D)	sponge
M. *parasitica* Lambe	(D)	sponge
Polymastia sp	(D)	sponge
Rhabdodermella nuttingi Urban	(C,D)	sponge
Suberitidae (family), unident.	(C)	sponge
Porifera, unident.	(B)	sponge
CNIDARIA		
Abietinaria spp	(D)	hydroid
Aglaophenia sp	(B,C,D)	ostrich-plume hydroid

Scientific Name	Occurrence	Common Name
CNIDARIA (cont.)		
Anthopleura artemisia (Pickering in Dana)	(C,D)	anemone
A. elegantissima (Brandt)	(B,D)	anemone
A. xanthogrammica (Brandt)	(B,C)	giant green anemone
Anthozoan, unident.	(B,C)	sea anemone
Astrangia lajollaensis Durham	(C)	solitary coral
Balanophyllia elegans Verrill	(C)	solitary coral
Campanularia sp	(B,D)	hydroid
Campanularidae (family), unident.	(D)	hydroid
Corymorpha palma Torrey	(C)	hydroid
Corynactis californica Carlgren	(C,D)	anemone
Epiactis prolifera Verrill	(C,D)	anemone
Eucopella sp (near caliculata)	(B,D)	hydroid
Eucopella sp	(C)	hydroid
Garveia annulata Nutting	(D)	hydroid
Hydroid, unident.	(B,C)	hydroid
Metridium exilis	(B,C,D)	anemone
Parazoanthus sp	(C)	parasitic anemone
Plumularia sp	(C,D)	hydroid
Sertularia sp	(D)	hydroid
Tealia crassicornis (Muller)	(B,D)	anemone
PLATYHELMINTHES		
Platyhelminthes, unident.	(C,D)	flatworm
NEMERTEA		
Nemerteans, unident.	(B,C,D)	ribbon worm

Scientific Name	Occurrence	Common Name
BRYOZOA		
Alcyonidium sp	(C,D)	bryozoan
Bowerbankia sp ?	(B)	bryozoan- Ectoprocta
Bugula sp	(B)	bryozoan
Caulibugula ciliata (Robertson)	(C)	bryozoan (moss animal)
Caulibugula sp	(D)	moss animal
Crisia maxima Robertson	(C,D)	moss animal
Crisia sp	(D)	moss animal
Diaperoecia californica (d'Orbigny)	(D)	moss animal
Filicrisia franciscana (Robertson)	(C)	moss animal
Flustrella corniculata (Smitt)	(C,D)	moss animal
Hippothoa hyalina (Linnaeus)	(A,C,D)	moss animal
Membranipora sp	(B,C)	encrusting bryozoan
Schizoporella sp	(B)	moss animal
Scrupocellaria sp	(C,D)	moss animal
Tubuliporidae, unident.	(D)	moss animal
PHORONIDA		
Phoronis sp	(B,C)	
NEMATODA		
Nematodes, unident.	(B,C,D)	round worm
ANNELIDA		
Anaitides williamsi Hartman	(B)	polychaete worm
Anaitides sp	(C,D)	polychaete worm
Aphrodita sp	(B)	polychaete worm
Arctonae vittata (Grube)	(C)	polychaete worm
Armandia bioculata Hartman	(C,D)	polychaete worm

Scientific Name	Occurrence	Common Name
ANNELIDA (cont.)		
Autolytus varius Treadwell	(B)	polychaete worm
Capitella capitata (Fabricius)	(B)	" "
Cirratulus cirratus (Muller)	(D)	" "
Diopatra ornata Moore	(B)	" "
D. splendidissima Kinberg	(B)	" "
Diopatra sp	(C,D)	" "
Dodecaceria fewkesi Berkeley and Berkeley	(D)	" "
D. fistulicola Ehlers	(D)	" "
Eteone sp ?	(D)	" "
Eudistylia sp	(C,D)	" "
Eulalia aviculiseta Hartman	(B,C,D)	" "
Flabelligeridae, unident.	(C,D)	" "
Genetyllis castanea (Marenzeller)	(B,D)	" "
Glycera sp	(B.C.D)	" "
Hirudinidae, unident.	(D)	leech
Laonice cirrata (Sars)	(C)	polychaete worm
Lumbrineris zonata (Johnson)	(D)	" "
Maldanidae, unident.	(C,D)	" "
Naineris dendritica (Kinberg)	(A,D)	" "
Nepthys sp	(D)	" "
Nereidiform (juvenile)	(B,C)	" "
Nereidae, unident.	(B)	" "
Nereis grubei Kinberg	(B,D)	" "
N. latescens Chamberlin	(B)	" "
Nereis sp	(D)	" "
Odontosyllis sp	(C,D)	" "
Ophelia sp	(C)	" "

Scientific Name	Occurrence	Common Name
ANNELIDA (cont.)		
Phyllochaetopterus prolifica Potts	(B,D)	polychaete worm
Pista pacifica Berkeley	(B)	" "
Pista sp	(B)	" "
Polydora sp	(D)	" "
Polynoidae (family), unident.	(B,D)	" "
Ramex californiensis Hartman	(B,C,D)	" "
Sabellidae, unident.	(B,C,D)	" "
Serpulidae (family), unident.	(B,C)	" "
Syllidae, unident.	(D)	" "
Typosyllis spp	(B,C,D)	" "
Typosyllis aciculata Treadwell	(A,B,C,D)	" "
T. alternata (Moore)	(D)	" "
SIPUNCULOIDEA		
Sipunculid, unident.	(B,D)	peanut worm
ARTHROPODA		
Pycnogonida and Chelicerata		
Ammothella sp	(B,C,D)	sea spider
Anoplodactylus nodosus Hilton	(C)	sea spider
Nymphon heterodenticulatum Hedgpeth	(D)	sea spider
Phoxichilidium femoratum (Rathke)	(D)	sea spider
Pycnogonum rickettsi (Schmitt)	(B)	sea spider
P. stearnsi Ives	(D)	sea spider

Scientific Name	Occurrence	Common Name
ARTHROPODA (cont.)		
Copepoda, Cirripeda, and Ostracoda		
Ostracods, unident.	(C,D)	ostracod
Copepods, cyclopoid, unident.	(A,D)	copepod
Copepods, harpacticoid, unident.	(A,D)	copepod
Balanus glandula Darwin	(A,B,C,D)	acorn barnacle
B. nubilis Darwin	(C,D)	acorn barnacle
Balanus sp	(B,C)	acorn barnacle
Pollicipes polymerus J. B. Sowerby	(B,C)	gooseneck barnacle
Pollicipes sp		gooseneck barnacle
Cumacea		
Cumella sp	(C)	cumacean
Diastylopsis sp	(D)	cumacean
Isopoda		
Anatanais normani (Richardson)	(A,B,D)	isopod, cheliferan
Cymothoidae (family), unident.	(A)	isopod
"*Dynamenella*" sp (near *benedicti*) Richardson, Menzies	(A)	isopod
Edotea sublittoralis Menzies	(D)	isopod
Exosphaeroma sp	(A)	isopod
Ianiropsis analoga Menzies	(C,D)	isopod
Ianiropsis sp	(B,C,D)	isopod
Idarcturus hedgpethi Menzies	(D)	isopod
Idothea (*Pentidotea*) *stenops* (Benedict)	(D)	isopod
Idothea (*Pentidotea*) sp	(B,D)	isopod
Isopod, unident.		isopod
Jaeropsis dubia Menzies	(C,D)	isopod

Scientific Name	Occurrence	Common Name
ARTHROPODA (cont.)		
Isopoda (cont.)		
Janiralata occidentalis (Walker)	(C)	isopod
Janiropsis sp	(D)	isopod
Leptochelia sp	(B,C,D)	isopod, cheliferan
Munna sp	(B,C,D)	isopod
Neastacilla sp	(D)	isopod
Synidotea consolidata (Stimpson)	(C,D)	isopod
S. *ritteri* Richardson	(B,C,D)	isopod
Synidotea sp	(C,D)	isopod
Caprellidea		
Caprella angusta Mayer	(B,C,D)	skeleton shrimp
C. *californica* Stimpson	(B,C,D)	skeleton shrimp
C. *equilibra* Say	(A,B,C,D)	skeleton shrimp
C. *incisa* Mayer	(B,C,D)	skeleton shrimp
C. *verrucosa* Boeck	(A,C,D)	skeleton shrimp
Caprella spp	(C,D)	skeleton shrimp
Caprellids, unident.	(B,C,D)	skeleton shrimp
Metacaprella anomala (Mayer)	(D)	
M. *ferra* (Mayer)	(D)	
Metacaprella sp (near *anomala*)	(D)	
Metacaprella spp	(B,C,D)	
Tritella pilimana Mayer	(B,C,D)	skeleton shrimp
Tritella sp	(D)	skeleton shrimp
Amphipoda		
Amphipods, corophid, unident.	(A,C,D)	amphipod
Amphipods, gammarid, unident.	(A,B,C,D)	amphipod

Scientific Name	Occurrence	Common Name
ARTHROPODA (cont.)		
Decapoda		
Blepharipoda occidentalis Randall	(B)	spiny mole crab
Cancer antennarius Stimpson	(B,C,D)	rock crab
C. gibbosulus (de Haan)	(B)	crab
Cancer sp	(D)	cancer crab
Loxorhynchus crispatus Stimpson	(D)	crab
Pachycheles rudis Stimpson	(C,D)	thick-clawed crab
Pagurid, unident.	(B,C,D)	hermit crab
Pagurus beringanus (Benedict)	(D)	hermit crab
Pugettia gracilis Dana	(B,D)	crab
MOLLUSCA		
Amphineura		
Chaetopleura gemma Carpenter in Pilsbry	(B)	chiton
Tonicella lineata (Wood)	(B,D)	lined chiton
Gastropoda		
Acmaea asmi (Middendorf)	(C)	limpet
A. digitalis Eschscholtz	(B,C)	file limpet
A. pelta Eschscholtz	(B,C)	limpet
Acmaea sp	(A)	limpet
Alvinia compacta (Carpenter)	(C)	snail
Amphissa columbiana Dall	(D)	snail
A. versicolor (Dall)	(D)	snail
Barleeia sp	(C)	snail
Buccinidae, unident.	(C)	whelk
Calliostoma annulatum Martyn	(C)	annulate top snail
C. canaliculatum (Lightfoot)	(D)	channeled top snail
C. costatum Martyn	(C)	snail
Calliostoma sp	(C)	top shell

Scientific Name	Occurrence	Common Name
MOLLUSCA (cont.)		
Gastropoda (cont.)		
Crepipatella lingulata (Gould)	(C)	half-slipper shell
Diodora aspera (Rathke)	(C)	rough keyhole limpet
Haliotis rufescens Swainson	(C)	red abalone
Lacuna carinata (Gould)	(B)	carinate lacuna
L. unifasciata Carpenter	(A,C,D)	one-banded lacuna
Lacuna sp	(D)	snail
Mangelia sp	(D)	snail
Mitrella carinata Sowerby	(D)	keeled dove shell
Ocenebra interfossa Carpenter	(D)	sculptured rock shell
O. lurida von Middendorf	(D)	lurid rock shell
Odostomia sp ?	(C)	pyramid shell
Olivella biplicata Sowerby	(B)	purple olive shell
O. pycna Berry	(D)	olive shell
Pteropurpura trialata (Sowerby)	(D)	three-winged murex snail
Thais sp	(B,C)	dogwinkle snail
Tricolia sp ?	(D)	snail
Trochidae (family), unident.	(C)	top shell
Turridae (family), unident.	(C)	turrid snail
Opisthobranchia and Tectibranchia		
Archidoris sp	(C,D)	sea slug
Cadlina luteomarginata MacFarland	(C,D)	sea slug
Cadlina sp	(D)	sea slug
Dialula sandiegensis (Cooper)	(C)	sea slug
Flabellina iodinea (Cooper)	(D)	sea slug

Scientific Name	Occurrence	Common Name
MOLLUSCA (cont.)		
Opisthobranchia and Tectibranchia (cont.)		
Hermissenda crassicornis (Eschscholtz)	(C,D)	sea slug
Nudibranch, aeolid, unident.	(A,B,D)	sea slug
Triopha sp	(C)	sea slug
Pelecypoda		
Chione sp	(B)	chione
Hiatella arctica (Linnaeus)	(B,C,D)	clam
Hinnites multirugosus (Gale)	(C,D)	rock scallop
Moliolus capax (Conrad)	(A,B)	capax horse mussel
M. *rectus* (Conrad)	(B)	straight horse mussel
Mytilus edulis Linnaeus	(A,B,C,D)	bay mussel
M. *californianus* Conrad	(B,C)	mussel
Philobrya setosa (Carpenter)	(B)	clam
Pododesmus crepia (Gray)	(C)	abalone jingle
Protothaca sp	(C)	littleneck clam
Tellina modesta (Carpenter)	(D)	clam
Volsella capax	(D)	horse mussel
Volsella sp	(C)	horse mussel
Pelecypoda, unident.	(C)	
Veneridae, unident.	(B,C,D)	venus clam
Cephalopoda		
Octopus sp	(B)	octopus

Scientific Name	Occurrence	Common Name
ECHINODERMATA		
Asteroidea		
Dermasterias imbricata (Grube)	(C,D)	leather star
Henricia leviscula (Stimpson)	(C,D)	red starfish
Leptasterias aequalis (Stimpson)	(B)	sea star
L. hexactis (Stimpson)	(D)	sea star
Leptasterias sp	(B)	six-arm star
Patiria miniata (Brandt)	(C,D)	bat star
Pisaster brevispinus (Stimpson)	(C,D)	sea star
P. giganteus (Stimpson)	(C)	sea star
P. ochraceus (Brandt)	(B,C,D)	sea star
Pycnopodia helianthoides (Brandt)	(B,C,D)	sea star
Ophiuroidea		
Amphiodia sp	(C,D)	serpent star
Ophiacantha sp	(C)	brittle star
Ophiothrix spiculata LeConte	(B)	brittle star
Ophiuroid, unident.	(B)	brittle star
Holothuroidea		
Holothuroidean, unident.	(D)	sea cucumber
Leptosynapta albicans (Selenka)	(B)	burrowing cucumber
UROCHORDATA		
Amaroucium californicum Ritter and Forsyth	(C)	colonial ascidian
A. solidum Ritter and Forsyth	(B)	compound ascidian
Amaroucium sp	(B,D)	ascidian
Distaplia occidentalis Bancroft	(D)	tunicate

Scientific Name	Occurrence	Common Name
UROCHORDATA (cont.)		
Polycitoridae, unident.	(D)	tunicate
Pycnoclavella stanleyi	(B)	tunicate
Synoicum sp	(D)	tunicate
VERTEBRATA		
Atherinops sp	(C)	smelt
Citharichthys stigmaeus (Girard)	(B)	speckled sanddab
Clinocottus sp	(B,C,D)	sculpin
Cymatogaster aggregata Gibbons	(B)	shiner perch
Embiotoca lateralis Agassiz	(C,D)	striped perch
Genyonemus lineatus (Ayres)	(D)	white croaker
Heterostichus rostratus Girard	(C,D)	giant kelp fish
Hexagrammos decagrammus (Pallas)	(B,C)	greenling
Hexagrammos sp	(D)	greenling
Hypsurus caryi (Agassiz)	(B)	rainbow perch
Ophiodon elongatus Girard	(C,D)	lingcod
Paralichthys californicus (Ayres)	(C)	California halibut
Platichthys stellatus (Pallas)	(C)	starry flounder
Rathbunella sp ?	(C)	ronquil
Sebastes chrysomelas (Jordan and Gilbert)	(C)	black and yellow rockfish
S. *flavidus* Ayres	(B,C,D)	yellowtail rockfish
S. *mystinus* (Jordan and Gilbert)	(B,C,D)	blue rockfish
S. *serranoides* Eigenmann and Eigenmann	(C)	olive rockfish

Scientific Name	Occurrence	Common Name
VERTEBRATA (cont.)		
Scorpaena guttata Girard	(C)	California scorpionfish
Scorpaenichthys marmoratus (Ayres)	(C)	cabezon
Triakis semifasciata Girard	(C)	leopard shark
flatfish, unident. (turbot?)	(B)	

Miscellaneous

Unidentified tubes (polychaete?)

Insect larvae -- Arthropoda

Intertidal Studies

Reference: Fig. 5-30

INTERTIDAL SURVEY
FAUNA
DUXBURY REEF, MARIN COUNTY

PORIFERA
Orange encrusting sponge

COELENTERATA
Anthopleura elegantissima
A. xanthogrammica
Tealia sp.

NEMERTEA
Paranemertina sp.

MOLLUSCA
Acmaea pelta
A. scabra
A. persona
Crepidula sp.
Mopalia mucosa
Mytilus californicus
Nassarius sp.
Olivella biplicata
Tegula brunnea
T. funebralis
Thais emarginata
Tonicella lineata

ARTHROPODA
Balanus sp.
Cthamalus sp.
Pagurus hirsutisculus
P. samuelis
Petrolisthes sp.
Pollicipes sp.

ECHINODERMATA
Leptasterias aequalis
Strongylocentrotus purpuratus

Marine plants from Duxbury Reef

Green algae

- Blidingia minima (Naeg.) Kylin
- Cladophora trichotoma (C. Ag.) Kuetz.
- Enteromorpha spp., incl. E. intestinalis (L.) Nees, E. linza (L.) J.Ag.
- Rhizoclonium tortuosum (Dillw.) Kuetz.
- Spongomorpha coalita (Rupr.) Collins
- Ulva spp., incl. U. lobata (Kuetz.) S. & G.
- Urospora penicilliformis (Roth) J. Aresch.

Brown algae

- Alaria marginata P. & R.
- Cystoseira osmundacea (Turn.) C. Ag.
- Desmarestia herbacea (Turn.) Lamour.
- Egregia menziesii (Turn.) J. Aresch.
- Fucus gardneri Silva
- Haplogloia andersonii (Farlow) Levring
- Heterochordaria abietina (Rupr.) S. & G.
- Laminaria setchellii Silva
- L. sinclairii (Hook. f. & Harv.) Farl. And. & Eat.
- Melanosiphon intestinalis (Saunders) Wynne
- Nereocystis luetkeana (Mert.) P. & R. [cast ashore]
- Pelvetia fastigiata (J. Ag.) De Toni
- Pelvetiopsis limitata (Setchell) Gardner
- Postelsia palmaeformis Rupr.
- Pterygophora californica Rupr.
- Scytosiphon dotyi Wynne
- S. lomentaria (Lyngbye) Endl.

Red algae

- Amplisiphonia pacifica Holl.
- Bossiella gardneri (Manza) Silva
- B. plumosa (Manza) Silva
- Botryoglossum farlowianum (J. Ag.) De Toni
- Calliarthron cheilosporioides Manza
- C. tuberculosum (P. & R.) Dawson
- Callithamnion pikeanum Harvey
- Callophyllis megalocarpa Setchell & Swezy
- C. pinnata Setchell & Swezy
- Corallina chilensis Decaisne
- C. vancouveriensis Yendo
- Cryptopleura lobulifera (J. Ag.) Kylin
- C. violacea (J. Ag.) Kylin
- Cryptosiphonia woodii J. Ag.
- Dilsea californica (J. Ag.)Schmitz
- Endocladia muricata (P. & R.) J. Ag.
- Erythrophyllum delesserioides J. Ag.
- Farlowia compressa J. Ag.
- F. mollis (Harv. & Bail.) Farlow & Setchell

Marine plants from Duxbury Reef

Gastroclonium coulteri (Harv.) Kylin
Gelidium coulteri Harvey
G. purpurascens Gardner
Gigartina agardhii S. & G.
G. californica J. Ag.
G. canaliculata Harvey
G. jardinii J. Ag.
G. papillata (C. Ag.) J. Ag.
Gonimophyllum skottsbergii Setchell
Gracilaria sjoestedtii Kylin
Grateloupia californica Kylin
Gymnogongrus leptophyllus J. Ag.
G. linearis (Turn.) J. Ag.
G. platyphyllus Gardner
Halosaccion glandiforme (Gmel.) Rupr.
Heteroderma nicholsii Setchell & L. Mason
Hymenena flabelligera (J. Ag.) Kylin
H. multiloba (J. Ag.) Kylin
Iridaea flaccida (S. & G.) Silva
I. heterocarpa P. & R.
I. sanguinea(S. & G.) Holl. & Abbott
I. splendens(S. & G.) Papenf.
Janczewskia Gardneri Setchell & Guernsey
Laurencia spectabilis P. & R.
Lithothamnium pacificum Foslie
Melobesia marginata Setchell & Foslie
M. mediocris (Foslie) Setchell & L. Mason
Microcladia borealis Rupr.
M. coulteri Harvey
Nienburgia andersoniana (J. Ag.) Kylin
Odonthalia floccosa (Esp.) Falk.
O. oregona Doty
Opuntiella californica (Farlow) Kylin
Phycodrys setchellii Skottsb.
Phyllophora clevelandii Farlow
Pikea californica Harvey
Pleonosporium dasyoides (J. Ag.) De Toni
Plocamium pacificum Kylin
Polycoryne gardneri Setchell
Polyneura latissima (Harv.) Kylin
Polyporolithon conchatum (Setch. & Fosl.) L. Mason
Polysiphonia collinsii Holl.
Porphyra perforata J. Ag.
Porphyrella gardneri G. M. Smith & Holl.
Prionitis andersoniana Eaton
P. lanceolata (Harvey) Harvey
Pterochondria woodii (Harvey) Holl.
Pterosiphonia bipinnata (P. & R.) Falk.
P. dendroidea (Mont.) Falk.
Ptilota californica Rupr.
P. densa C. Ag.
P. filicina (Farlow) J. Ag.
P. hypnoides Harvey

Marine plants from Duxbury Reef

Rhodochorton obscurum Drew
R. subimmersum S. & G.
Rhododermis elegans Crouan frat.
Rhodomela larix (Turn.) C. Ag.
Rhodymenia pacifica Kylin
Schizymenia pacifica (Kylin) Kylin
Smithora naiadum (And.) Holl.
Spermothamnion snyderae Farlow
Stenogramma californica Harvey

Flowering plant
Phyllospadix

INTERTIDAL SURVEY
FAUNA
ROCKY POINT, MARIN COUNTY

PORIFERA

Rhabdodermella nuttingi

COELENTERATA

Aglaophenia sp.
Anthopleura elegantissima
Anthopleura xanthogrammica
Obelia sp.
Sertularella sp.

ANNELIDA

Nereis sp.
Encrusting worm

MOLLUSCA

Acmaea pelta
A. persona
A. scabra
Calliostoma sp.
Hermissenda crassicornis
Littorina sp.
Mytilus californicus
M. edulis
Tegula funebralis
Thais emarginata
Tonicella lineata

ARTHROPODA

Balanus glandula
Cancer sp. (juv.)
Chthamalus dalli
Hemigrapsus nudus
Idothea sp.
Pachygrapsus crassipes
Pagurus hirsutisculus
P. samuelis
Petrolisthes sp.
Pollicipes polymerus

ECHINODERMATA

Leptasterias aequalis
Pisaster ochraceous

Marine plants from Rocky Point

Green algae
- Blidingia minima (Naeg.) Kylin
- Spongomorpha coalita (Rupr.) Collins
- Urospora penicilliformis (Roth) J. Aresch.

Brown algae
- Alaria marginata P. & R.
- Egregia menziesii (Turn.) J. Aresch.
- Laminaria sinclairii (Hook. f. & Harv.) Farl. And. & Eat.
- Petalonia fascia (O. F. Muell.) Kuntze
- Ralfsia pacifica Holl.

Red algae
- Ahnfeltia plicata (Huds.) Fries
- Bossiella gardneri (Manza) Silva
- B. plumosa (Manza) Silva
- Callithamnion pikeanum Harvey
- Constantinea simplex Setchell
- Corallina vancouveriensis Yendo
- Dilsea californica (J. Ag.) Schmitz
- Endocladia muricata (P. & R.) J. Ag.
- Erythrophyllum delesserioides J. Ag.
- Gastroclonium coulteri (Harv.) Kylin
- Gelidium coulteri Harvey
- Gigartina canaliculata Harvey
- G. jardinii J. Ag.
- Gymnogongrus linearis (Turn.) J. Ag.
- Hildenbrandia occidentalis Holl.
- Hymenena flabelligera (J. Ag.) Kylin
- H. multiloba (J. Ag.) Kylin
- Iridaea flaccida (S. & G.) Silva
- I. splendens (S. & G.) Papenf.
- Microcladia borealis Rupr.
- Nienburgia andersoniana (J. Ag.) Kylin
- Odonthalia floccosa (Esp.) Falk.
- Pikea californica Harvey
- Plocamium pacificum Kylin
- P. violaceum Farlow
- Polysiphonia spp.
- Porphyra lanceolata (Setch. & Hus) G. M. Smith
- P. perforata J. Ag.
- Prionitis filiformis Kylin
- P. lanceolata (Harvey) Harvey
- Pterosiphonia dendroidea (Mont.) Falk.
- Ptilota filicina (Farlow) J. Ag.
- Rhodomela larix (Turn.) C. Ag.
- Schizymenia pacifica (Kylin) Kylin

Flowering plant
- Phyllospadix

INTERTIDAL SURVEY
FAUNA
BONITA COVE, MARIN COUNTY

PORIFERA
Rhabdodermella nuttingi

COELENTERATA
Aglaophenia sp.
Anthopleura elegantissima
A. xanthogrammica
Sertularella sp.

MOLLUSCA
Acmaea pelta
Littorina sp.
Littorina planaxis
L. scutula
Mopalia sp.
Mytilus sp.
M. californicus
Nassarius sp.
Rostangia sp.
Tonicella lineata

ARTHROPODA
Cancer productus
Chthamalus dalli
Idothea sp.
Pollicipes polymerus
Pugettia producta

ECHINODERMATA
Leptasteria aequalis
Pisaster ochraceous

Marine plants from Bonita Cove

Green algae
- Blidingia minima (Naeg.) Kylin
- Enteromorpha linza (L.) J. Ag.
- Ulva vexata S. & G.
- Urospora penicilliformis (Roth) J. Aresch.

Brown algae
- Alaria marginata P. & R.
- Cystoseira osmundacea (Turn.) C. Ag.
- Egregia menziesii (Turn.) J. Aresch.
- Laminaria setchellii Silva
- L. sinclairii (Hook. f. & Harv.) Farl. And. & Eat.
- Pelvetiopsis limitata (Setchell) Gardner
- Petalonia fascia (O. F. Muell.) Kuntze
- Ralfsia pacifica Holl.

Red algae
- Besa papillaeformis Setchell
- Bossiella gardneri (Manza) Silva
- B. plumosa (Manza) Silva
- Callithamnion pikeanum Harvey
- Ceramium eatonianum (Farlow) De Toni
- Corallina vancouveriensis Yendo
- Cryptopleura violacea (J. Ag.) Kylin
- Dilsea californica (J. Ag.) Schmitz
- Endocladia muricata (P. & R.) J. Ag.
- Gastroclonium coulteri (Harv.) Kylin
- Gigartina jardinii J. Ag.
- G. papillata (C. Ag.) J. Ag.
- Hildenbrandia occidentalis Setchell
- Hymenena flabelligera (J. Ag.) Kylin
- H. multiloba (J. Ag.) Kylin
- Iridaea heterocarpa P. & R.
- Kylinia porphyrae (Drew) Papenf.
- Laurencia spectabilis P. & R.
- Melobesia mediocris (Foslie) Setchell & L. Mason
- Microcladia borealis Rupr.
- M. coulteri Harvey
- Nienburgia andersoniana (J. Ag.) Kylin
- Odonthalia floccosa (Esp.) Falk.
- Pikea californica Harvey
- Plocamiocolax pulvinata Setchell
- Plocamium pacificum Kylin
- P. violaceum Farlow
- Polysiphonia collinsii Holl.
- Porphyra lanceolata (Setch. & Hus) G. M. Smith
- P. perforata J. Ag.
- Prionitis filiformis Kylin
- P. lanceolata (Harvey) Harvey
- Pterochondria woodii (Harvey) Holl.
- Rhodomela larix (Turn.) C. Ag.
- Schizymenia pacifica (Kylin) Kylin

Flowering plant
- Phyllospadix

INTERTIDAL SURVEY
FAUNA
LAND'S END, CITY OF SAN FRANCISCO

COELENTERATA
Anthopleura elegantissima
Anthopleura xanthogrammica

MOLLUSCA
Acmaea sp.
A. pelta
A. persona
A. scabra
Littorina planaxis
Moralis hindsii
Mytilus sp.
Mytilus californicus
Thais emarginata

ARTHROPODA
Balanus sp.
B. glandula
Chthamalus dalli
Pollicipes polymerus

ECHINODERMATA
Pisaster ochraceous

Marine plants from Lands End, 1897-1913

Green algae
- Blidingia minima (Naeg.) Kylin
- Rhizoclonium tortuosum (Dillw.) Kuetz.
- Ulva vexata S. & G.

Brown algae
- Alaria marginata P. & R.
- Laminaria sinclairii (Hook. f. & Harv.) Farl. And. & Eat.
- Pelvetiopsis limitata (Setchell) Gardner
- Petalonia fascia (O. F. Muell.) Kuntze
- *Postelsia palmaeformis Rupr.
- *Pylaiella gardneri Collins

Red algae
- Ahnfeltia gigartinoides J. Ag.
- A. plicata (Huds.) Fries
- Bangia vermicularis Harvey
- Besa papillaeformis Setchell
- *Botryoglossum farlowianum (J. Ag.) De Toni
- *Callithamnion pikeanum Harvey
- *C. rupicolum And.
- *Constantinea simplex Setchell
- Corallina densa (Collins) Doty
- Cryptosiphonia woodii J. Ag.
- *Cumagloia andersonii (Farlow) S. & G.
- *Dilsea californica (J. Ag.) Schmitz
- *Endocladia muricata (P. & R.) J. Ag.
- Gigartina papillata (C. Ag.) J. Ag.
- *G. volans (C. Ag.) J. Ag.
- *Gloiosiphonia verticillaris Farlow
- *Gonimophyllum skottsbergii Setchell
- Gymnogongrus linearis (Turn.) J. Ag.
- Hildenbrandia occidentalis Setchell
- *Hymenena flabelligera (J. Ag.) Kylin
- *H. kylinii Gardner
- *H. multiloba (J. Ag.) Kylin
- *Iridaea flaccida (S. & G.) Silva
- *I. heterocarpa P. & R.
- *Kylinia porphyrae (Drew) Papenf.
- *Lithothamnium californicum Foslie
- *Microcladia borealis Rupr.
- *Odonthalia floccosa (Esp.) Falk.
- *Petrocelis franciscana S. & G.
- *Plocamium pacificum Kylin
- P. violaceum Farlow
- *Porphyra perforata J. Ag.
- Prionitis filiformis Kylin
- P. lanceolata (Harvey) Harvey
- Rhodochorton rothii (Turt.) Naeg.
- Rhodomela larix (Turn.) C. Ag.
- *Smithora naiadum (And.) Holl.
- *Stenogramma californica Harvey

Flowering plant
- Phyllospadix

*Species not found in 1970-1971

Marine plants from Lands End, 1970-1971

Green algae
- Blidingia minima (Naeg.) Kylin
- Rhizoclonium tortuosum (Dillw.) Kuetz.
- Ulva vexata S. & G.

Brown algae
- Alaria marginata P. & R.
- Laminaria sinclairii (Hook. f. & Harv.) Farl. And. & Eat.
- Pelvetiopsis limitata (Setchell) Gardner
- Petalonia fascia (O. F. Muell.) Kuntze
- Ralfsia pacifica Holl.

Red algae
- Ahnfeltia gigartinoides J. Ag.
- A. plicata (Huds.) Fries
- Bangia vermicularis Harvey
- Besa papillaeformis Setchell
- Corallina densa (Collins) Doty
- Cryptosiphonia woodii J. Ag.
- Gigartina papillata (C. Ag.) J. Ag.
- Gymnogongrus linearis (Turn.) J. Ag.
- Hildenbrandia occidentalis Setchell
- Plocamium violaceum Farlow
- Porphyra lanceolata (Setch. & Hus) G. M. Smith
- Prionitis filiformis Kylin
- P. lanceolata (Harvey) Harvey
- Rhodochorton rothii (Turt.) Naeg.
- Rhodomela larix (Turn.) C. Ag.

INTERTIDAL SURVEY
FAUNA
ROCKAWAY BEACH, SAN MATEO COUNTY

COELENTERATA
Aglaophenia sp.
Anthopleura elegantissima
A. xanthogrammica
Eudendrium californium
Sertularella sp.

NEMERTEA
Nemertina sp.

SIPUNCULIDA
Dendrostomum dyscritum

MOLLUSCA
Acmaea paleacea
A. pelta
Cyanoplax dentiens
Hermissenda crassicornis
Homalopoma sp.
Littorina planaxis
L. scutula
Margarites sp.
Mopalia sp.
Mytilus sp.
Mytilus californicus
Pholadidea penita
Rostangia sp.
Tegula funebralis
Thais emarginata
Tonicella lineata

ARTHROPODA
Balanus glandula
Cthamalus dalli
Cthamalus sp.
Pachygrapsus crassipes
Pagurus hirsutisculus
P. samuelis
Pollicipes polymerus
Pugettia sp..

ECHINODERMATA
Pisaster ochraceous

Marine plants from Rockaway Beach

Green algae
- Cladophora graminea Collins
- Codium setchellii Gardner
- Spongomorpha coalita (Rupr.) Collins
- Urospora penicilliformis (Roth) J. Aresch.

Brown algae
- Alaria marginata P. & R.
- Laminaria setchellii Silva
- L. sinclairii (Hook. f. & Harv.) Farl. And. & Eat.
- Petalonia fascia (O. F. Muell.) Kuntze
- Ralfsia pacifica Holl.

Red algae
- Ahnfeltia gigartinoides J. Ag.
- A. plicata (Huds.) Fries
- Anisocladella pacifica Kylin
- Bossiella gardneri (Manza) Silva
- B. plumosa (Manza) Silva
- Botryoglossum farlowianum (J. Ag.) De Toni
- Callithamnion pikeanum Harvey
- Corallina vancouveriensis Yendo
- Cryptopleura violacea (J. Ag.) Kylin
- Cryptosiphonia woodii J. Ag.
- Dilsea californica (J. Ag.) Schmitz
- Endocladia muricata (P. & R.) J. Ag.
- Erythrophyllum delesserioides J. Ag.
- Gastroclonium coulteri (Harv.) Kylin
- Gelidium robustum (Gardner) Holl. & Abbott
- Gigartina agardhii S. & G.
- G. canaliculata Harvey
- G. papillata (C. Ag.) J. Ag.
- G. volans (C. Ag.) J. Ag.
- Gracilaria sjoestedtii Kylin
- Gracilariophila oryzoides Setchell & Wilson
- Gymnogongrus leptophyllus J. Ag.
- G. linearis (Turn.) J. Ag.
- Hildenbrandia occidentalis Setchell
- Hymenena flabelligera (J. Ag.) Kylin
- H. multiloba (J. Ag.) Kylin
- Iridaea flaccida (S. & G.) Silva
- Kylinia porphyrae (Drew) Papenf.
- Laurencia spectabilis P. & R.
- Leptocladia conferta Setchell
- Melobesia mediocris (Foslie) Setchell & L. Mason
- Microcladia borealis Rupr.
- Nienburgia andersoniana (J. Ag.) Kylin

Marine plants from Rockaway Beach

Odonthalia floccosa (Esp.) Falk.
Phycodrys setchellii Skottsberg
Pikea californica Harvey
Plocamium oregonum Doty
P. pacificum Kylin
P. violaceum Farlow
Polysiphonia spp.
Porphyra perforata J. Ag.
Prionitis andersoniana Eaton
P. lanceolata (Harvey) Harvey
Ptilota filicina (Farlow) J. Ag.
Rhodoglossum affine (Harvey) Kylin
Rhodomela larix (Turn.) C. Ag.
Schimmelmannia plumosa (Setchell) Abbott
Schizymenia pacifica (Kylin) Kylin
Spermothamnion snyderae Farlow
Stenogramma californica Harvey

INTERTIDAL SURVEY
FAUNA
MOSS BEACH, SAN MATEO COUNTY

COELENTERATA
- Balanophyllia sp.
- Aglaophenia sp.
- Anthopleura elegantissima
- A. xanthogrammica
- Sertularella sp.

MOLLUSCA
- Acmaea mitra
- A. persona
- A. pelta
- A. scabra
- Calliostoma sp.
- C. costatum
- Crepidula sp.
- Mopalia mucosa
- Mytilus californicus
- Nassarius sp.
- Pholadidea sp.
- Tegula brunnea
- T. funebralis
- Thais sp.
- Thais lamellosa
- Vermitida sp..

ARTHROPODA
- Balanus sp.
- B. cariosus
- B. tintabulum
- Cancer antennarius
- Chthamalus sp.
- Hemigrapsus nudus
- Pagurus hirsutisculus
- P. samuelis
- Petrolisthes sp.
- Pugettia producta

ECHINODERMATA
- Leptasterias aequalis
- Pisaster ochraceous
- Strongyocentrotus purpuratus

Marine plants from Moss Beach

Green algae
- Blidingia minima (Naeg.) Kylin
- Bryopsis corticulans Setchell
- Cladophora trichotoma (C. Ag.) Kuetz.
- Collinsiella tuberculata S. & G.
- Enteromorpha spp., incl. E. linza (L.) J. Ag.
- Monostroma zostericola Tilden
- Spongomorpha coalita (Rupr.) Collins
- Ulva lobata (Kuetz.) S. & G.

Brown algae
- Alaria marginata P. & R.
- Costaria costata (Turn.) Saunders
- Cystoseira osmundacea (Turn.) C. Ag.
- Desmarestia herbacea (Turn.) Lamour.
- Egregia menziesii (Turn.) J. Aresch.
- Fucus gardneri Silva
- Haplogloia andersonii (Farlow) Levring
- Heterochordaria abietina (Rupr.) S. & G.
- Laminaria setchellii Silva
- Melanosiphon intestinalis (Saunders) Wynne
- Nereocystis luetkeana (Mert.) P. & R. [cast ashore]
- Pelvetia fastigiata (J. Ag.) De Toni
- Pelvetiopsis limitata (Setchell) Gardner
- Petrospongium rugosum (Okam.) S. & G.
- Phaeostrophion irregulare S. & G.
- Postelsia palmaeformis Rupr.
- Scytosiphon lomentaria (Lyngbye) Endl.
- Soranthera ulvoidea P. & R.

Red algae
- Agardhiella coulteri (Harvey) Setchell
- Amplisiphonia pacifica Holl.
- Bornetia californica Abbott
- Bossiella gardneri (Manza) Silva
- B. plumosa (Manza) Silva
- Botryoglossum farlowianum (J. Ag.) De Toni
- Calliarthron tuberculosum (P. & R.) Dawson
- Callithamnion pikeanum Harvey
- Callophyllis crassifolia Setchell & Swezy
- C. firma (Kylin) Norris
- C. megalocarpa Setchell & Swezy
- C. pinnata Setchell & Swezy
- Corallina vancouveriensis Yendo
- Cryptopleura lobulifera (J. Ag.) Kylin
- C. violacea (J. Ag.) Kylin
- Cryptosiphonia woodii J. Ag.
- Cumagloia andersonii (Farlow) S. & G.

Marine plants from Moss Beach

Delesseria decipiens J. Ag.
Endocladia muricata (P. & R.) J. Ag.
Erythrophyllum delesserioides J. Ag.
Farlowia compressa J. Ag.
F. mollis (Harv. & Bail.) Farlow & Setchell
Gastroclonium coulteri (Harv.) Kylin
Gelidium coulteri Harvey
G. purpurascens Gardner
G. robustum (Gardner) Holl. & Abbott
Gigartina agardhii S. & G.
G. californica J. Ag.
G. canaliculata Harvey
G. corymbifera (Kuetz.) J. Ag.
G. papillata (C. Ag.) J. Ag.
Gonimophyllum skottsbergii Setchell
Grateloupia californica Kylin
Gymnogongrus platyphyllus Gardner
Halosaccion glandiforme (Gmel.) Rupr.
Halymenia californica G. M. Smith & Holl.
Heteroderma nicholsii Setchell & L. Mason
Hymenena flabelligera (J. Ag.) Kylin
H. multiloba (J. Ag.) Kylin
Iridaea flaccida (S. & G.) Silva
I. heterocarpa P. & R.
I. splendens (S. & R.) Papenf.
Laurencia spectabilis P. & R.
Lithothamnium californicum Foslie
L. pacificum Foslie
Melobesia marginata Setchell & Foslie
M. mediocris (Foslie) Setchell & L. Mason
Membranoptera multiramosa Gardner
Microcladia corealis Rupr.
M. coulteri Harvey
Odonthalia floccosa (Esp.) Falk.
Opuntiella (Farlow) Kylin
Peyssonelia pacifica Kylin
Phycodrys setchellii Skottsb.
Pikea californica Harvey
Pleonosporium dasyoides (J. Ag.) De Toni
Plocamium pacificum Kylin
P. violaceum Farlow
Polyneura latissima (Harv.) Kylin
Polyporolithon conchatum (Setch. & Fosl.) L. Mason
P. parcum (Foslie) L. Mason
Polysiphonia spp., incl. P. pacifica Holl.
Porphyra perforata J. Ag.
Prionitis andersoniana Eaton
P. filiformis Kylin
P. lanceolata (Harv.) Harvey
P. linearis Kylin

Pseudogloiophloea confusa (Setchell) Levring
Pterochondria woodii (Harvey) Holl.
Pterosiphonia bipinnata (P. & R.) Falk.
P. dendroidea (Mont.) Falk.
Ptilota densa C. Ag.
Rhodochorton subimmersum S. & G.
Rhodoglossum americanum Kylin
Rhodomela larix (Turn.) C. Ag.
Schizymenia pacifica (Kylin) Kylin
Serraticardia macmillani (Yendo) Silva
Smithora naiadum (And.) Holl.

Flowering plant
Phyllospadix

Species or Other Groups Collected from
Floats and Docks in Gashouse Cove on 8 October 1970

Species	Number	Remarks
ALGAE		
Antithamnion sp	P	
Ceramium Gardneri	P	
Colpomenia bullosus	P	
Cryptopleura lobulifera	P	
Fucus distichus subsp *edentatus*	P	
Gigartina californica	P	
Laminaria Sinclairii	P	
Microcladia sp	P	
Polyneura latissima	P	
Polysiphonia Brodiaei	P	
Prionitis Andersonii	P	
Ulva expansa	P	
PROTOZOA		
Foraminiferidae		
Elphidiella sp	P	in silty debris
Pulvinulina sp	P	
BRYOZOA		
Hippothoa hyalina	P	on algae
ANNELIDA		
Naineris dendritica	3	
Syllidae, unident.	3	badly mutilated
Typosyllis aciculata	2	

P - Present

A - Abundant

Species	Number	Remarks
ARTHROPODA		
Crustacea		
Copepoda		
Copepods, cyclopoid, unident.	A	two species in association with filamentous algae
Copepods, harpacticoid, unident.	A	two species in association with filamentous algae
Cirripedia		
Balanus glandula	6	on algae
Malacostraca		
Chelifera		
Anatanais normani	5	
Isopoda		
Cymothoidae, unident.	1	juvenile
"*Dynamenella*" sp (near *benedicti*)	4	
Exosphaeroma sp	4	juvenile
Amphipoda		
Caprella equilibra	1	
C. verrucosa	1	
Amphipods, corophid, unident.	12	
Amphipods, gammarid, unident.	38	
MOLLUSCA		
Gastropoda		
Acmaea sp	1	juvenile, 3.5 mm
Lacuna unifasciata	19	

Species	Number	Remarks
MOLLUSCA (cont.)		
Opisthobranchia		
Nudibranch, aeolid, unident.	6	less than 1-1.5 mm
Pelecypoda		
Modiolus capax	4	3-6 mm with *Mytilus* in holdfast
Mytilus edulis	31	in algae holdfast

In-Situ Cage Studies

Reference: Fig. 5-29

BIOASSAY DATA

TYPE In-Situ Toxicity OBSERVER J. Hawke DURATION 4 - 8 days

SUBJECT ORGANISM THREESPINE STICKLEBACK EFFLUENT WATER SOURCE PIER 35 PIER 39

GASTERSTEUS ACULEATUS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4	5	6	7	8	
1	control		12				12	12		12		4/20/70 to 4/27/70
	Pier 35		12				9	6		3		
	Pier 39		12				8	6		5		
2	control		15	15	15		15					4/27/70 to 5/1/70
	Pier 35		15	7	1		0					
	Pier 39		15	9	2		1					
3	control		15	15	15	15	15					5/12/70 to 5/16/70
	Pier 35		15	15	15	15	13					
	Pier 39		15	15	14	11	5					
4	control		15	15	15	15	15				15	5/18/70 to 5/26/70
	Pier 35		15	13	10	7	4				2	
	Pier 39		15	5	5	4	4				4	
5 Fish adjusted to Pier 7	control		5	5	5	5			*			5/26/70 to 6/1/70
	Pier 35		5	5	5	5			5			
	Pier 39		5	4	4	4			4			

* cage stolen

Data used in preparation of Table 5-9

Reference Figures

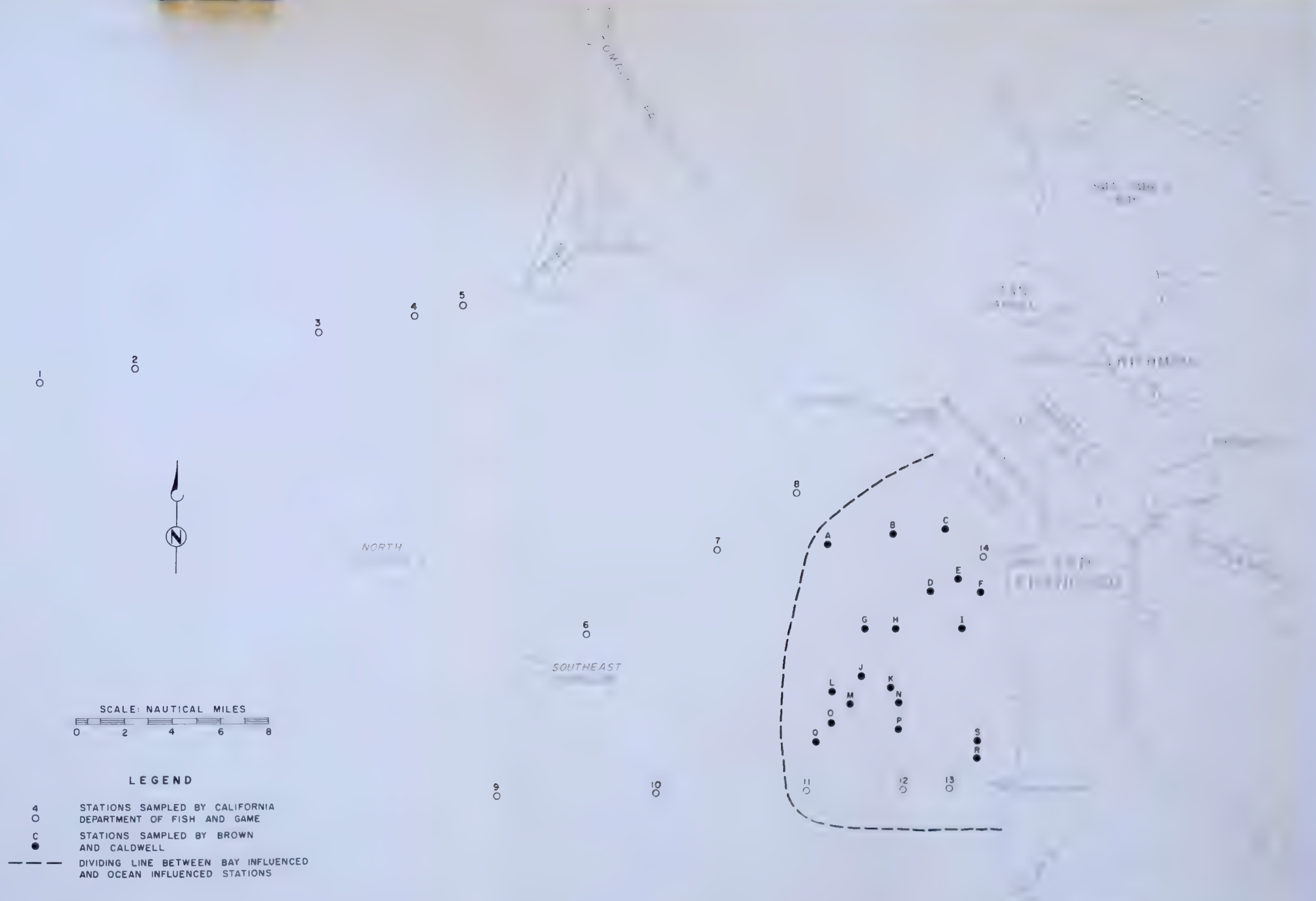

Fig. 5-17 Plankton Sampling Stations, 1970

Fig. 5-27 Location of Benthic Sampling Stations and Community Types

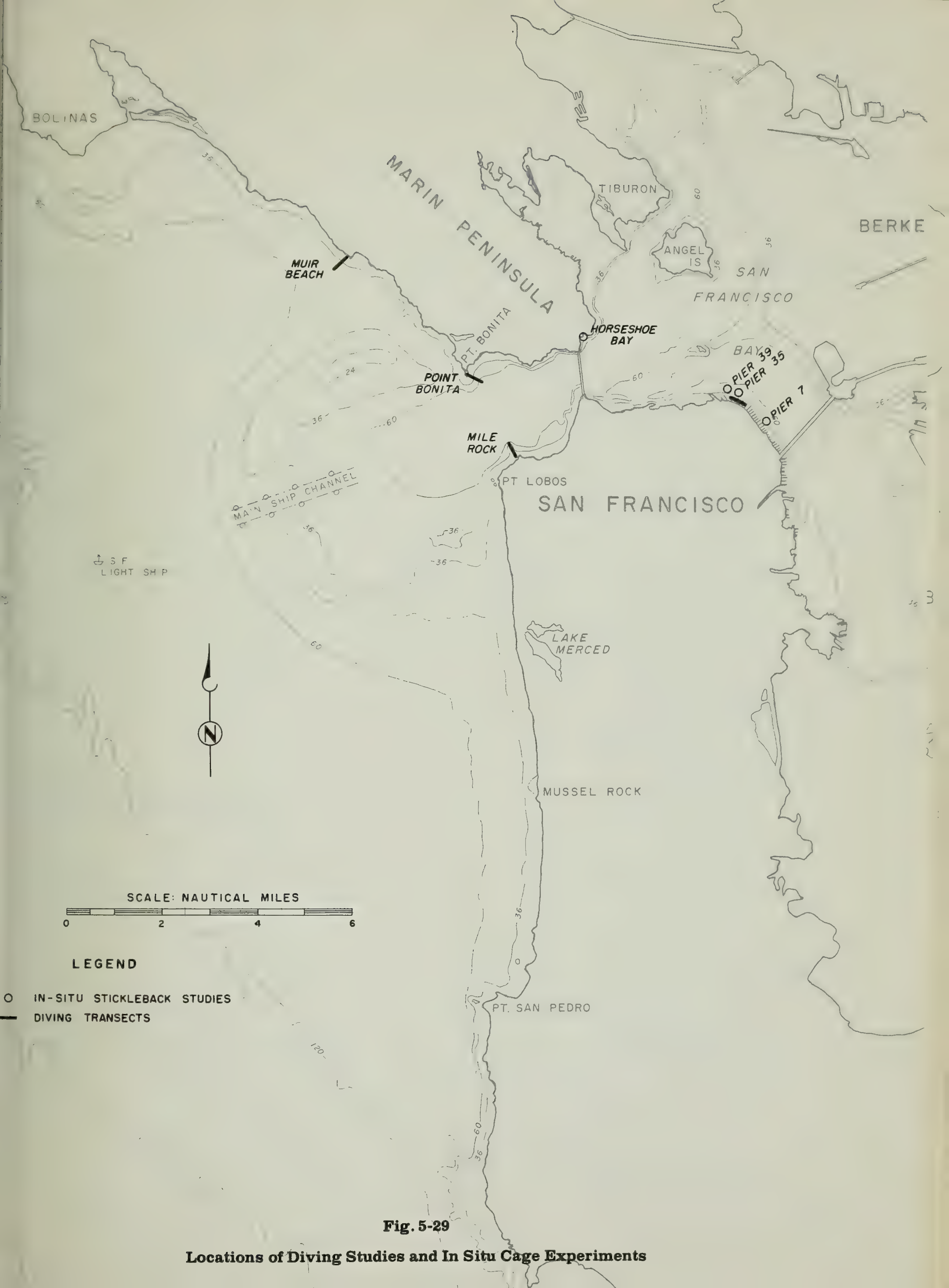

Fig. 5-29

Locations of Diving Studies and In Situ Cage Experiments

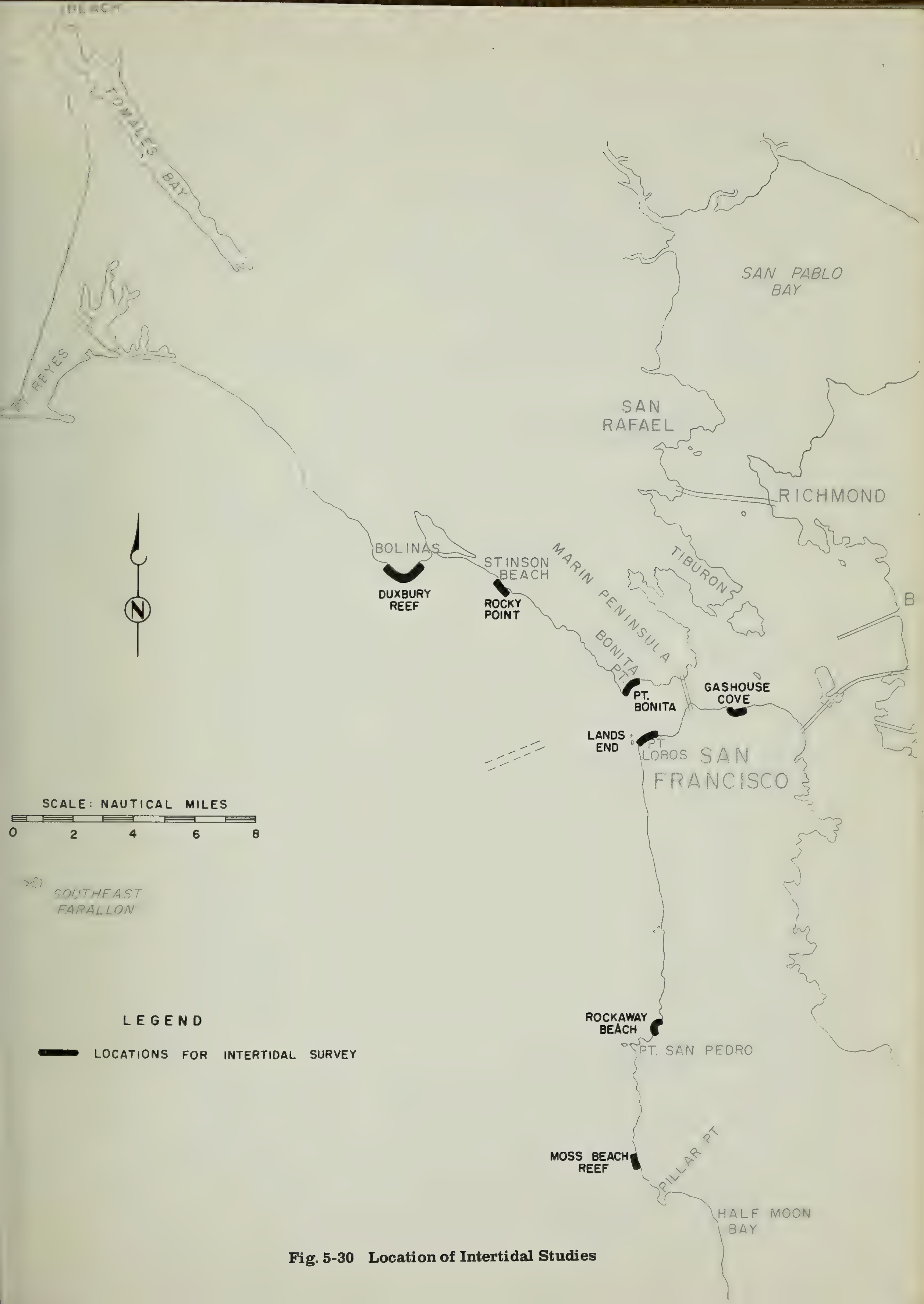

Fig. 5-30 Location of Intertidal Studies

LABORATORY DATA

Static Bioassays

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM SHINER PERCH EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

CYMATOGASTER AGGREGATA

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
1 7/25/70	control	5 liter	10	-	9	-	8					
	1:50		10	-	8	-	6					
	1:10		10	-	9	-	10					
	1:5		10	-	10	-	10					
2 7/25/70	control	5 liter	20	-	18	-	14					
	1:20		20	-	19	-	14					s - Salinity adjusted
	1.5		20	-	16	-	11					
3 7/30/70	control	5 liter	15	-	15	-	12					p - Salinity not adjusted
	1:20		15	-	14	-	12					
	1:10		15	-	14	-	14					
	1:5		15	-	14	-	13					
4 9/7/70	control	5 liter	7	7	7	-	5					
	1:5		7	6	5	-	4					
	1:2		7	6	4	-	2					
	1:2		7	6	6	-	3					
5 8/15/70	control	5 liter	10	-	10	-	10					
	1:2s		10	-	10	-	1					
	1:2		10	-	8	-	1					
	1:1s		10	-	0	-	0					
	1:1		10	-	0	-	0					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM WALLEYE PERCH EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

HYPERPROSOPON ARGENTEUM

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)								
			0	1	2	3	4				
6 9/10/70	control	5 liter	2	2	2	-	2				
	1:5		2	2	2	-	1				
	1:5		2	1	1	-	0				
	1:5		2	2	2	-	2				
7 7/11/70	control	5 liter	6	-	6	-	6				
	1:100		6	-	6	-	6				
	1:50		6	-	6	-	6				
8 7/26/70	control	5 liter	15	-	15	-	15				
	1:100		15	-	15	-	15				
	1:50		15	-	15	-	15				
9 8/2/70	control	5 liter	6	-	-	-	5				
	1:20		6	-	-	-	5				
	1:10		6	-	-	-	5				
	1:5		6	-	-	-	5				

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM SAND DAB EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

CITHARICHTHYS SORDIDUS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4					
0 8/19/70	control	5 liter	6	-	6	-	6					
	1:2s		6	-	6	-	6					
	1/2		6	-	6	-	6					
	1/1s		6	-	6	-	5					
	1/1		6	-	5	-	2					s - Salinity adjusted
1 7/19/70	control	5 liter	7	-	7	-	7					
	1/20		7	-	7	-	7					
	1/10		7	-	7	-	6					
	1/5		7	-	6	-	6					
2 7/19/70	control	5 liter	13	-	13	-	13					
	1/20		13	-	13	-	12					
	1/10		13	-	13	-	10					
	1/5		13	-	13	-	12					
3 7/19/70	control	5 liter	5	5	5	-	5					
	1/1s a		5	5	5	-	5					
	1/1s b		5	5	4	-	4					
	1/1 a		5	5	5	-	5					
	1/1 b		5	5	5	-	5					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM LING COD EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

OPHIODON ELONGATUS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4					
14 7/19/70	control	10 liter	10	-	10	-	10					
	1:100		10	-	10	-	10					
	1:50		10	-	10	-	10					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM SCULPIN EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

SCORPAENA GUTTATA

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)								
			0	1	2	3	4				
5 7/26/70	control	30 liter	13	-	13	-	13				
	1/100		13	-	13	-	13				
	1/50		13	-	13	-	13				
6 7/26/70	control	5 liter	5	-	5	-	4				
	1/20		5	-	4	-	4				
	1/10		5	-	4	-	4				
	1/5		5	-	5	-	4				

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM ROCK BASS EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

SEBASTODES SP.

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4					
17 7/26/70	control	5 liter	10	-	10	-	10					
	1:20		10	-	10	-	10					
	1:10		10	-	10	-	10					
	1:5		10	-	10	-	10					
	1:2s		10	-	10	-	10					
	1:2		10	-	10	-	10					
	1:1s		10	-	10	-	10					s - Salinity adjust
	1:1		10	-	10	-	9					
	1:0s		10	-	2	-	0					
18 7/26/70	control	65 liter	30	-	30	-	30					
	1/100		30	-	30	-	30					
	1/50		30	-	30	-	30					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM STICKLEBACK EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

GASTEROSTEUS ACULEATUS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4					
8/7/70	control	5 liter	10	-	10	-	9					
	1/100		10	-	9	-	9					
	1/50		10	-	9	-	9					
	1/2s		10	-	9	-	6					
	1/2		10	-	10	-	9					
	1/1s		10	-	7	-	3					
	1/1		10	-	10	-	8					
8/7/70	control a	5 liter	10	-	10	-	10					s - Salinity adjusted
	control b		10	-	10	-	10					p - Salinity not adjusted
	control c		10	-	10	-	10					
	1/20 a		10	-	10	-	10					
	1/20 b		10	-	10	-	10					
	1/20 c		10	-	10	-	10					
	1/10 a		10	-	10	-	10					
	1/10 b		10	-	10	-	10					
	1/10 c		10	-	10	-	10					
	1/5 a		10	-	10	-	10					
	1/5 b		10	-	10	-	10					
	1/5 c		10	-	10	-	10					
	control	5 liter	10	-	10	-	10					
	1/0 s		10	-	0	-	0					
	1/0 p		10	-	0	-	0					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM STICKLEBACK EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

GASTEROSTEUS ACULEATUS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4					
22 8/22/70	control	5 liter	10	10	10		7					
	1s/2 1		10	10	10	-	10					
	1s/2 2		10	10	10	-	10					
	1p/2 3		10	10	10	-	10					
	1p/2 4		10	10	10	-	10					
	1s/1 5		10	10	9	-	9					s - Salinity adjus
	1s/1 6		10	10	10	-	9					
	1/1 7		10	10	10	-	6					p - Salinity not a
	1/1 8		10	10	10	-	3					
	1s/0 9		10	5	5	-	1					
	1s/0 10		10	3	1	-	0					
	1/0 11		10	8	8	-	7					
	1/0 12		10	8	8	-	7					
23 8/25/70	control	5 liter	10	9	8	-	7					
	1/100 1*		10	10	10	-	10					
	1/50 2*		10	10	10	-	10					
	1/20 3*		10	10	10	-	10					
	1/10 4*		10	10	10	-	10					
	1/5 5*		10	9	7	-	3					
	1/2 6*		10	10	10	-	10					
	1/1 7*		10	10	10	-	10					
	1/0 8*		10	10	7	-	7					

* GASTEROSTEUS ACCLIMATED TO FRESH WATER

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM HERMIT CRAB EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

PAGURUS SAMUELIS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
7/13/70	control	5 liter	7	-	7	-	7					
	1/100		7	-	7	-	7					
	1/50		7	-	7	-	7					
6/13/70	control	5 liter	7	-	7	-	7					
	1/100		7	-	7	-	7					
	1/50		7	-	7	-	7					
6/13/70	control	5 liter	7	-	7	-	6					
	1/100		7	-	7	-	7					
	1/50		7	-	7	-	6					
6/13/70	control	5 liter	4	4	4	4	4					
	1/20		4	4	4	4	4					
	1/10		4	4	4	4	4					
	1/5		4	4	4	4	4					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM SHORE CRAB EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

HEMIGRAPSUS OREGONENSIS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
29 7/12/70	control	5 liter	30	-	30	-	30					
	1/100		30	-	30	-	30					
	1/50		30	-	30	-	30					
30 7/19/70	control	5 liter	30	-	30	-	30					
	1/100		30	-	28	-	28					
	1/50		30	-	29	-	29					
31 7/19/70	control	5 liter	30	-	28	-	25*					
	1/100		30	-	26	-	22*					
	1/50		30	-	29	-	27*					* Escaped/ no morta
32 7/26/70	control	30 liter	30	-	29	-	28					
	1/20		30	-	30	-	29					
	1/10		30	-	29	-	29					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM SAND CRAB EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

EMERITA ANALOGA

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
3 8/7/70	control	10 liter	17	-	-	-	14					
	1/100		17	-	-	-	13					
	1/50		17	-	-	-	10					
	1/20		17	-	-	-	12					s - Salinity adjusted
	1/10		17	-	-	-	6					
	1/2s		17	-	-	-	0					
	1/2		17	-	-	-	0					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM BAY SHRIMP EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

CRAGO SP.

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
34 9/15/70	Control A	10 liter	15	15	9	-	8					
	1/100		15	14	8	-	6					
	1/50		15	14	9	-	6					
	1/20		15	13	7	-	7					
	1/10		15	14	8	-	6					
	1/5		15	15	8	-	5					
	1s/2		15	14	7	-	0					s - Salinity adjusted
	1p/2		15	15	8	-	0					p - Salinity not adjusted
	1s/1		15	13	5	-	0					
	1p/1		15	10	4	-	0					
	1s/0		15	0	-	-	-					
	1p/0		15	0	-	-	-					
	Control B	10 liter	15	15	9	-	8					
	1/100		15	14	6	-	7					
	1/50		15	14	6	-	5					
	1/20		15	13	7	-	7					
	1/10		15	14	8	-	5					
	1/5		15	15	7	-	5					
	1s/2		15	14	7	-	0					
	1p/2		15	15	8	-	0					
	1s/1		15	13	4	-	0					
	1p/1		15	11	6	-	0					
	1s/0		15	0	-	-	-					
	1p/0		15	0	-	-	-					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM BAY SHRIMP EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

CRAGO SP.

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
5 7/27/70	control	5 liter	10	-	10	-	8					
	1/100		10	-	10	-	8					
	1/50		10	-	10	-	7					
	1/10		10	-	9	-	7					
	1/5		10	-	9	-	7					
	1/2s		10	-	8	-	7					
	1/2		10	-	9	-	9					s - Salinity adjusted
	1/1s		10	-	5	-	3					
	1/1		10	-	4	-	3					
	1/05		10	-	0	-	0					
	1/0		10	-	0	-	0					
6 7/19/70	control	5 liter	10	-	-	-	8					
	1/100		10	-	-	-	8					
	1/50		10	-	-	-	7					
	1/10		10	-	-	-	7					
	1/5		10	-	-	-	7					
	1/2s		10	-	-	-	7					
	1/2		10	-	-	-	9					
	1/1s		10	-	-	-	3					
	1/1		10	-	-	-	3					
	1/0s		10	-	-	-	0					
	1/0		10	-	-	-	0					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM GHOST SHRIMP EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

CALLIANASSA CALIFORNIENSIS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)								
			0	1	2	3	4				
37 8/7/70	control	5 liter	16	-	16	-	16				
	1/100		16	-	16	-	16				
	1/50		16	-	16	-	16				

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM TURBAN SNAIL EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

TEGULA FUNEBRALIS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
28 8/16/70	CONTROL	5 liter	18	-	18	-	18					
	1/20		18	-	18	-	18					
	1/10		18	-	18	-	17					
	1/5		18	-	18	-	18					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM PURPLE SEA URCHIN EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

STRONGLOCENTRUS PURPURATUS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)								
			0	1	2	3	4				
38 8/7/70	control	10 liter	10	-	10	-	10				
	1/100		10	-	10	-	10				
	1/50		10	-	10	-	10				

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM BENT-NOSED CLAM EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

MACOMA NASUTA

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4					
39 8/7/70	control	5 liter	11	-	11	-	11					
	1/100		11	-	11	-	11					
	1/50		11	-	11	-	11					
	1/20		11	-	11	-	11					s - Salinity adjusted
	1/10		11	-	11	-	11					
	1/5		11	-	11	-	10					
	1/2s		11	-	11	-	10					
	1/2		11	-	11	-	11					
	1/1s		11	-	11	-	11					
	1/1		11	-	11	-	9					
	1/05		11	-	0	-	0					
	1/0		11	-	0	-	0					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM RIBBED HORSE MUSSEL EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

VOLCELLA DEMISSA

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4					
40 8/7/70	control	10 liter	10	10	10	-	10					
	1/20		10	10	10	-	10					s - Salinity adjuste
	1/10		10	10	10	-	10					
	1/5		10	10	10	-	10					p - Salinity not adj
	1s/2		10	10	10	-	10					
	1p/2		10	10	10	-	10					
	1s/1		10	10	10	-	10					
	1p/1		10	10	10	-	10					
	control		10	10	10	-	10					
41 8/7/70	control	10 liter	10	10	10	-	10					
	1/1000		10	10	10	-	10					
	1/750		10	10	10	-	10					
	1/50		10	10	10	-	10					

BIOASSAY DATA

TYPE STATIC OBSERVER TRITICO DURATION 4 DAY

SUBJECT ORGANISM BROKEN-BACK SHRIMP EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

SPIRONTOCARIS PALUDICOLA

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)								
			0	1	2	3	4				
42 7/19/70	control	5 liter	10	-	10	-	10				
	1/100		10	-	10	-	9				
	1/50		10	-	10	-	9				
	1/1		10	-	9	-	7				

Environmental Chamber Bioassays

ENVIRONMENTAL CHAMBER BIOSSAY

Description Eggs C. magister Observer Glimme Date Commenced 4/30/70 Experiment No. EG-4

No. of Organisms 96-105 Container 1/2 gal. Jars Background Water Steinhart Food Source None

Date	Dilution	Survivors: HATCHED Zoea	Survivors: HATCHED Pre-Zoea	Notes
4/30	control			105 eggs removed from adult
	1:100			100 eggs
	1:50			96 eggs
	1:20			100 eggs Set up in S. F. composite (frozen)
4/30 to 5/7				Water and sewage changed at 48 hour intervals Checked for hatch at 24 hour intervals
5/7				First hatch noticed 30 hours from last check
	control	65	0	
	1:100	66	0	
	1:50	31	2	
	1:20	26	3	Changed water Zoea removed from eggs and kept in separate container
5/9	control	89	2	
	1:100	93	7	
	1:50	35	28	
	1:20	42	37	Changed water
5/11	control	89	2	
		93	7	
		35	29	
		42	44	Changed water
5/13	control	89	2	11 eggs dead Uncounted eggs are assumed to have decomposed
	1:100	93	7	0 eggs dead
	1:50	35	29	22 eggs dead
	1:20	42	44	13 eggs dead

Data used in preparation of Fig.5-33

ENVIRONMENTAL CHAMBER BIOSSAY

Description 1 day ZOEA C. MAGISTER Observer GLIMME Date Commenced 4/23/70 Experiment No. BB

No. of Organisms 25 Container Weight Boats Background Water Steinhart Food Source A. salina naupl

Date	Dilution	Survivors	Notes
			50 ml H_2O
4/24	control	25	
1 day	1:50	22	1 dead due to handling (dead zoea put in 5% formalin) Changed water and sewage (frozen) 12 hour mortality checks
4/25	control	25	
2 day	1:50	20	Changed water and sewage (frozen)
4/26	control	22	
3 day	1:50	17	Changed water and sewage (frozen)
4/27	control	21	
4 days	1:50	13	4 zoea missing Changed water and sewage (frozen)
4/29	control	21	(dead zoea put in new preservative - 1/2 glycerin and 1/2 70% ethanol)
	1:50	12	Changed frozen sewage
5/1	control	18	
8 days	1:50	9	Changed (frozen sewage)
5/4	control	16	
11 days	1:50	9	Changed (frozen sewage)
5/5	control	15	
12 days	1:50	8	Changed (frozen sewage)
5/7	control	15	
14 days	1:50	7	Changed (frozen sewage)
5/9	control	12	3 skins (exuviae)
16 days	1:50	6	2 skins (exuviae) Changed (frozen sewage)
5/11	control	8	2 skins
18 days	1:50	2	Changed (frozen sewage)
5/13	control	5	
20 days	1:50	2	Changed (frozen sewage)
5/15	control	4	
22 days	1:50	1	Changed (frozen sewage)
5/18	control	3	1 skin
25 days	1:50	1	Changed (frozen sewage)

ENVIRONMENTAL CHAMBER BIOSSAY

Description ______________ Observer__________ Date Commenced ______ Experiment No. BB

No. of Organisms __________ Container _________ Background Water __________ Food Source _______________

Date	Dilution	Survivors	Notes
5/20	control	3	2 skins
27 days	1:50	1	Changed (frozen sewage)
5/21	control	3	
28 days	1:50	1	Changed (frozen sewage)
			5/23 - 5/29 Changed water and sewage every 48 hours. No zoea died.
6/1	control	2	Approximately 4.5 mm long
47 days	1:50	1	Changed (frozen sewage)
			6/3 - 6/21 Changed water and sewage about every 48 hours. No zoea died.
6/25	control	2	1 normal and healthy and 1 lethargic
63 days	1:50	1	Lethargic Changed water and sewage (frozen)
6/26	control	1	Normal and healthy (changed water and sewage
64 days	1:50	0	last one died (discontinued)
			6/27 and 6/29 changed water and sewage - the zoea was healtl
7/1	control	0	last zoea died (4th stage)
69 days			

Data used in preparation of Fig. 5-34 and Table 5-16.

ENVIRONMENTAL CHAMBER BIOSSAY

Description 1 day ZOEA C. MAGISTER Observer GLIMME Date 4/23/70 Commenced ______ Experiment No. EX 1

No. of Organisms 50 Container Petri Dish Background Water 50 ml Steinhart Food Source A. salina naupl

Date	Dilution	Survivors	Notes
			S. F. Composite frozen used in experiment
4/24	control	49	
1 day	1:100	49	12 hour checks for mortality
	1:50	50	24 hour changes of water and sewage
	1:20	50	Dead zoea preserved in 5% formalin
4/25	control	49	1 moribund
2 days	1:100	47	
	1:50	45	2 moribund
	1:20	50	
4/26	control	48	
3 days	1:100	45	1 moribund
	1:50	43	
	1:20	49	
4/27	control	48	
4 days	1:100	45	Zoea checked and water and sewage changed about every 48 hours after 4/27
	1:50	43	
	1:20	49	
4/29	control	48	new preservative used for dead zoea - 1/2 glycerin and 1/2 70% ethanol
6 days	1:100	42	
	1:50	43	
	1:20	47	
5/1	control	48	
8 days	1:100	42	
	1:50	42	
	1:20	46	
5/4	control	45	
11 days	1:100	40	
	1:50	39	
	1:20	34	
5/5	control	44	
12 days	1:100	38	
	1:50	37	
	1:20	33	
5/7	control	31	1 skin
14 days	1:100	33	
	1:50	37	
	1:20	31	1 skin

ENVIRONMENTAL CHAMBER BIOSSAY

Description ______________ Observer __________ Date Commenced ______ Experiment No. EX. 1

No. of Organisms __________ Container __________ Background Water __________ Food Source ______________

Date	Dilution	Survivors	Notes
5/9	control	0	(discontinued)
16 days	1:100	15	
	1:50	15	
	1:20	4	
5/13	1:100	1	
20 days	1:50	1	Sewage discontinued
	1:20	0	(discontinued)
5/15	1:100	0	(experiment
22 days	1:50	0	discontinued)

Data used in preparation of Fig. 5-34 and Table 5-16.

Description 1 day ZOEA C. MAGISTER   Observer GLIMME   Date 4/23/70
Commenced ______   Experiment No. EX. 2
No. of Organisms 63 - 68   Container PETRI DISH   Background 50 ml
Water Steinhart   Food Source A. salina naupl

Date	Dilution	Survivors	Notes
4/23	control	63	S. F. Composite effluent (frozen samples)
	1:100	68	Initial number of organisms
	1:50	67	Dead zoea preserved
	1:20	67	Changed water and sewage at each count
4/24	control	62	
	1:100	66	Dropped 1:100 after count and could not recove
	1:50	65	
	1:20	65	
4/25	control	61	2 moribund
	1:50	62	1 moribund
	1:20	62	
4/26	control	58	
	1:50	61	
	1:20	61	
4/27	control	58	
4 days	1:50	61	
	1:20	61	
4/29	control	55	Dead zoea placed in new preservative
	1:50	59	
	1:20	60	
5/1	control	40	
	1:50	52	
	1:20	52	
5/4	control	11	
	1:50	38	
	1:20	38	
5/5	control	7	
	1:50	32	
	1:20	34	
5/7	control	0	
	1:50	-	Most dead) no count taken - zoea left in
	1:20	-	Most dead) containers to verify death

ENVIRONMENTAL CHAMBER BIOSSAY

Description ______ Observer ______ Date Commenced ______ Experiment No. EX. 2

No. of Organisms ______ Container ______ Background Water ______ Food Source ______

Date	Dilution	Survivors	Notes
5/11	1:50	7	
	1:20	1	
5/13	1:50	5	
	1:20	1	
5/15	1:50	0	
22 days	1:20	0	all dead (discontinued)
			Heavy protozoan infestation on dead zoea

Data used in preparation of Fig. 5-34 and Table 5-16.

Description 1 DAY ZOEA C. MAGISTER Observer GLIMME Date Commenced 4/23/70 Experiment No. EX. 3

No. of Organisms 75 - 151 Container 1/2 gal. jars Background Water Steinhart Food Source A. salina naupl

Date	Dilution	Survivors	Notes
4/23	control	75	initial number of zoea at each dilution Chamber 50°
	1:100	151	Sewage is S. F. Composite (frozen).
	1:50	123	Water and sewage changed at each count
	1:20	143	500 ml. of aerated water in each container; Dead zoea preserved in 5% formalin
4/24	control	75	
	1:100	151	
	1:50	122	
	1:20	143	
4/25	control	74	1 moribund
	1:100	145	1 moribund
	1:50	114	2 moribund
	1:20	138	1 moribund
4/26	control	72	
	1:100	139	2 moribund
	1:50	112	1 moribund
	1:20	136	2 moribund
4/27 4 days	control	71	
	1:100	134	
	1:50	110	
	1:20	131	
4/29	control	70	new preservative used for dead zoea - 1/2 blycerin and 1/2 70% ethanol
	1:100	130	
	1:50	110	
	1:20	126	
5/1	control	68	
	1:100	122	
	1:50	106	
	1:20	117	
5/5	control	61	
	1:100	83	
	1:50	73	
	1:20	98	
5/7 14 days	control	13	
	1:100	40	25 skins (Discontinued)
	1:50	1	
	1:20	4	

Data used in preparation of Fig. 5-34 and Table 5-

ENVIRONMENTAL CHAMBER BIOSSAY

Description 5 DAY ZOEA C. MAGISTER Observer GLIMME HJELLE Date Commenced 8/3/70 Experiment No. JA 33

No. of Organisms 33 Container Petri Dish Background Water Bay filtered Food Source A. salina nauplii

Date	Dilution	Survivors		Notes
/5	Control	30		Much food left
	1:100	26		Much food left
	1:50	26		Much food left Chamber 11°C
				Water changed and S.F. composite sewage from 8/4 added
				Fed zoea
/7	control	7		All sticky with fungal and protozoan infestation
days	1:100	10		Chamber 12°C
	1:50	10		
				Changed and fed (no sewage added after 4 day exposure) Experiment transferred to 16 oz. museum jars and set up on shaker (gentle motion for one hour four times a day, in an attempt to reduce fungal and protozoan growth).
/9	control	6		
	1:100	9		Stalked protista - fungus on carapace
	1:50	8		Stalked protista - fungus on carapace
		1st Stage	2nd Stage	
/13	control	5		1 lethargic good food left (fungus-protista)
6 days	1:100	5		good food left (fungus-protista)
	1:50	5	1	good food left (light fungus on 1st stage - some with heavy protista infestation)
				Removed from shaker (afraid of too much abrasion during molting of zoea)
		1st Stage	2nd Stage	
/15	control	0	3	Clean and healthy
	1:100	4	1	2nd stage zoea clean and healthy - transferred to separate container (100 - 2)
	1:50	5	1	2nd stage zoea clean and healthy - transferred to separate container (50 - 2)
/18	control	0	1	little food left
	1:100	3	0	little food left (many dead nauplii)
	1:100 - 2	0	1	little food left
	1:50	1	1	very little food left (2nd stage zoea transferred to 50 - 2)
	1:50 - 2	0	0	
/19	control	0	1	
	1:100	1	1	1st stage has fungus second stage is clean and transferred to 100 - 2 good food in all dilutions
	1:100 - 2	0	1	
	1:50	0	0	terminated
	1:50 - 2	0	0	terminated

ENVIRONMENTAL CHAMBER BIOSSAY

Description ______________ Observer __________ Date Commenced ______ Experiment No. JA 33

No. of Organisms __________ Container __________ Background Water __________ Food Source __________

Date	Dilution	Survivors		Notes
		1st Stage	2nd Stage	
8/21	control	0	0	Good food 1 dead with light fungus (discontinued)
	1:100	1	0	Good food moderate fungus
	1:100 - 2	0	2	Good food Healthy and clean
8/24	1:100	0	0	Fungus on dead zoea (terminated)
	1:100 - 2		2	Good food (a little fungus on one zoea)
8/26	1:100 - 2		2	Good food left
8/29	1:100 - 2		2	Little food left 1 zoea with light fungus
		2nd Stage	3rd Stage	
9/1	1:100 - 2	1	1	2nd stage has fungus good food left 1 skin
9/4	1:100 - 2		1	Good food left 2 nd stage died
9/5 - 9/11			1	3 rd stage zoea lived well
9/25			1	Barely alive
9/27		0	0	Dead (terminated) Heavy fungus

Data used in preparation Fig. 5-35.
Ref. fig. 5-35

ENVIRONMENTAL CHAMBER BIOSSAY

Description 20 DAY ZOEA C. MAGISTER Observer GLIMME HJELLE Date Commenced 8/11/70 Experiment No. JU22

No. of Organisms 8 Container Petri Dish Background Water Bay ~~Filtered~~ Food Source A. salina nauplii

Date	Dilution	Survivors 1st Stage	Survivors 2nd Stage	Notes
8/11	Control A	1	7	Initial set up with 50 ML filtered bay water and fresh
	Control B	2	6	S.F. composite from 8/10
	1:100A	1	7	
	1:100B	2	6	
	1:50A	1	7	Water and sewage changed at each check.
	1:50B	2	6	
8/13 2 days	Control A		2	Much food left - some fungus
	Control B		4	Much food left - some fungus
	1:100A		6	Much food left - some fungus
	1:100B	1	5	Much food left - some fungus
	1:50A		4	Much food left - some fungus - 1 skin
	1;50B		4	Much food left - some fungus - one with heavy fungus
				Sewage dated 8/10 added
8/15 4 days	Control A		2	Good food left
	Control B		4	Fair food left
	1:100A		1	Good food left
	1:100B		3	Good food left
	1:50A		3	Good food left
	1:50B		2	Good food left
				Sewage dated 8/10 added
8/18 7 days	Control A		1	Some food left
	Control B		2	Little food left
	1:100A		∅	Little food left - Discontinued
	1:100B		1	Little food left
	1:50A		∅	Little food left - Discontinued
	1:50B		1	Little food left - light fungus
				Sewage from 8/16 added
				Maintained for long term and stage studies

Date	Dilution	2nd Stage	Notes
8/19	Control A	1	Light fungus
	Control B	2	Heavy fungus removed from 1 - Light fungus left on both
	1:100B	1	Light fungus
	1:50B	1	Light fungus
			Sewage from 8/16 added
8/22	Control A	1	Heavy fungus and protozoans (major mass removed)
	Control B	2	1 with heavy fungus - 1 with light fungus, protozoans
	1:100B	∅	Terminated
	1:50B	1	Heavy fungus and protozoans (major mass removed)
			Sewage from 8/21 added

Description ____________ Observer ________ Date Commenced ______ Experiment No. JU 22

No. of Organisms ________ Container ________ Background Water ________ Food Source ________

Date	Dilution	Survivors	Notes
8/24	Control A	1	Moderate fungus
	Control B	2	Very heavy fungus (subjected to 25 minute long wave U.V. li
	1:50B	1	
			Sewage discontinued due to fungal infestation
8/26	Control A	1	U.V. treatment 2 minute exposure - heavy protista infestati
	Control B	2	Sterile water (U.V. treated) - mild fungus, heavy protista
	1:50B	1	Mild fungus - heavy protista
8/29	Control A	1	Covered with protozoans
	Control B	2	Fungus and protozoans (one to each molting)
	1:50B		Heavily covered with fungus
9/1	Control A	1	Lethargic
	Control B	∅	Both 2nd stage - heavy fungus both dead - Terminated
	1:50B	∅	Mild fungus - dead - Terminated
9/4	Control A	∅	Experiment terminated

Data used in preparation of Fig. 5-36

ENVIRONMENTAL CHAMBER BIOSSAY

Description SAND CRAB 1 DAY ZOEA EMERITA   Observer GLIMME HJELLE   Date Commenced 7/16/70   Experiment No. EM 1

No. of Organisms 30   Container Petri Dish   Background Water Bay Filtered   Food Source A. salina nauplii

Date	Dilution	Survivors	Notes
7/18	Control 1	27	S. F. fresh composite (cold storage)
2 days	Control 2	26	a. No salinity adjustment attempted.
	Control 3	28	b. Salinity adjusted in effluent 25 gms.
	1:100	24	Reagent grade per liter effluent.
	1:50	22	c. Traces of life but unable to determine viability
	1:20	25	of zoea.
	1:10	26	
	1:2[a]	30	
	1:2[b]	28	Water and sewage changed at each check.
	2:1[a]	c	
	2:1[b]	c	2:1 = 2 parts sewage to 1 part bay water
7/20	Control 1	25	
4 days	Control 2	19	
	Control 3	20	
	1:100	24	
	1:50	16	
	1:20	22	
	1:10	11	
	1:2[a]	ø	(terminated)
	1:2[b]	8	sewage discontinued (fresh bay water only).
	2:1[a]	ø	(terminated)
	2:1[b]	ø	(terminated)
7/23	Control 1	24	
7 days	Control 2	19	
	Control 3	18	
	1:100	24	all zoea active and healthy
	1:50	15	
	1:20	22	
	1:10	11	
	1:2[b]	ø	(terminated)
7/25			all zoea active and healthy
			water not changed - food added
7/27	Control 1	24	No food left
	Control 2	19	Little food left
	Control 3	19	Little food left
	1:100	24	Little food left
	1:50	15	Some food left
	1:20	21	Little food left
	1:10	11	Good food left

ENVIRONMENTAL CHAMBER BIOSSAY

Description SAND CRAB 1 DAY ZOEA EMERITA Observer GLIMME HJELLE Date Commenced 7/16/70 Experiment No. EM 1

No. of Organisms 30 Container Petri Dish Background Water Bay Filtered Food Source A. salina nau

Date	Dilution	Survivors 1st Stage	Survivors 2nd Stage	Notes
7/29	Control 1		24	Much food left 1 skin (exuviae)
	Control 2		17	Good food left 1 with fungus
	Control 3		19	Much food left
	1:100		24	Good food left
	1:50		15	Much food left 1 skin
	1:20		19	Much food left 1 with white growth (normal otherwise)
	1:10		9	Much food left
				Sewage from 7/28/70 added
7/31				No count taken
				Skins in all dilutions
				Water changed and new food added
8/4	Control 1	0	21	No food
	Control 2	1	14	No food 1 skin
	Control 3	0	17	Very little food Chamber 11°C
	1:100	0	19	No food
	1:50	0	11	Very little food 1 skin - Growth inside carapace
	1:20	1	4	Very little food 2 skins - 1st stage moldy but alive
	1:10	2	5	Much food 1 skin
				Sewage from 7/28 added
8/7	Control 1		12	
	Control 2		13	
	Control 3		17	Fungus in carapace more pronounced
	1:100	19	19	
	1:50		10	
	1:20		1	Barely alive
	1:10		7	3 with short rostrums - heavy fungus

ENVIRONMENTAL CHAMBER BIOSSAY

Description SAND CRAB 1 DAY ZOEA EMERITA Observer GLIMME HJELLE Date Commenced 7/16/70 Experiment No. EM1

No. of Organisms 30 Container Petri Dish Background Water Bay Filtered Food Source A. salina nauplii

Date	Dilution	Survivors 2nd Stage	Notes
8/11	Control 1	11	No food left
	Control 2	12	No food left
	Control 3	16	No food left
	1:100	16	No food left
	1:50	7	Little food left
	1:20	∅	Some food (terminated)
	1:10	3	Little food - heavy protista infestation of water fungus in carapace 2 with short rostrums - 1 with long rostrum
			Sewage from 8/10 added
8/13	Control 1	11	Good food left
	Control 2	10	Good food left (Debris and old food)
	Control 3	15	Fair food left
	1:100	12	Good food left
	1:50	9	Good food left
	1:10	2	Good food left - 1 with fungus
			Sewage from 8/10 added
8/16	Control 1	4	Much food left - 2 lethargic
	Control 2	7	Some food left - 1 lethargic
	Control 3	9	Some food left - 1 lethargic
	1:100	10	Little food left - 1 lethargic
	1:50	7	Little food left
	1:10	2	Some food left - 1 very lethargic
			Sewage from 8/10 added
8/18	Control 1	3	Good food left
	Control 2	7	Little food left
	Control 3	8	Little food left - 5 lethargic
	1:100	9	Some food left - 1 lethargic
	1:50	6	Good food left - 4 lethargic
	1:10	1	Good food left
			Sewage from 8/16 added
8/19	Control 1	3	Good food left
	Control 2	6	Good food left
	Control 3	6	Good food left - 2 lethargic
	1:100	8	Good food left
	1:50	4	Good food left
	1:10	1	Good food left
			Sewage from 8/16 added

ENVIRONMENTAL CHAMBER BIOSSAY

Description SAND CRAB 1 DAY ZOEA EMERITA Observer GLIMME HJELLE Date Commenced 7/16/70 Experiment No. EM 1

No. of Organisms 30 Container Petri Dish Background Water Bay Filtered Food Source A. salina naup

Date	Dilution	Survivors 2nd Stage	Survivors 3rd Stage	Notes
8/22	Control 1	1		Good food left - Fungus in carapace
	Control 2	5		Good food left - Light to moderate fungus
	Control 3	2		Good food left - Light fungus - heavy protózoans
	1:100	6		Good food left - Light fungus
	1:50	4		Good food left - Moderate fungus
	1:10	1		Good food left - Light fungus
				Sewage from 8/21 added
8/24	Control 1	∅	∅	Good food left - Terminated
	Control 2	3		Good food left - 2 with light fungus - lethargic
	Control 3	2		Good food left - 2 lethargic
	1:100	5		Good food left - 3 with light fungus - lethargic
	1:50	2		Good food left - 2 with light fungus - lethargic
	1:10	∅	∅	Good food left - Terminated
				Sewage from 8/21 added
8/26	Control 2	1	1	Good food left
	Control 3	1	∅	Good food left - Heavy fungus
	1:100	1	2	Much food left
	1:50	∅	∅	Good food left - Terminated - Very heavy protista and fungus
				Sewage from 8/21 added
8/29	Control 2	∅	1	Little food left - Heavy fungus
	Control 3	∅	∅	Terminated
	1:100	∅	3	Little food left - Heavy fungus
				Sewage from 8/21 added
9/1	Control 2	∅	∅	Terminated
	1:100	∅	∅	Terminated - Protozoans

Data used in preparation of Fig. 5-37 and Table 5-16

ENVIRONMENTAL CHAMBER BIOSSAY

BROKEN BACK SHRIMP
1 DAY ZOEA

Description SPIRONTOCARIS Observer GLIMME Date Commenced 7/14/71 Experiment No. SP

No. of Organisms 10 Container Petri Dish Background Bay Water Filtered Food Source A. salina nauplii

Date	Dilution	Survivors	Notes
			50ML H_2O filtered through #20 mesh plankton netting and fresh S.F. composite in each container (except control).
/15	Control	10	
	1:100	9	
	1:50	10	
/18	Control	10	
	1:100	9	
	1:50	9	Experimented terminated at 96 hours.

Data used in preparation of Table 5-16

ENVIRONMENTAL CHAMBER BIOSSAY

Description BAY SHRIMP 1 DAY ZOEA CRAGO   Observer GLIMME HJELLE   Date Commenced 8/18/71   Experiment No. C03-8

No. of Organisms 30   Container Petri Dish   Background Water Bay Filtered   Food Source A. salina naup

Date	Dilution	Survivors	Notes
			50ML H_2O and fresh S. F. composite used
8/10 2 days	Control	22	
	1:100	13	
	1:50	13	
	1:20	12	
	1:10	15	3 lethargic
			Sewage from 8/4/ added
8/12 4 days	Control	16	Much food left
	1:100	6	Much food left
	1:50	9	Much food left
	1:20	6	Much food left
	1:10	6	Much food left
			Sewage from 8/10 added
8/14 6 days	Control	11	Good food left
	1:100	3	Good food left
	1:50	6	Fair food left
	1:20	4	Much food left
	1:10	2	Good food left
			Sewage from 8/10 added
8/17 9 days	Control	9	Good food left - 3 lethargic
	1:100	2	Good food left - 1 lethargic Experiment Discontinued
	1:50	3	Good food left - 2 lethargic
	1:20	2	Good food left - 1 lethargic
	1:10	1	Good food left - 1 lethargic

Data used in preparation of Fig. 5-38 and Table 5-16

Continuous Flow Bioassays

BIOASSAY DATA

TYPE Continuous Flow OBSERVER Bill Moffett DURATION 4 days

SUBJECT ORGANISM Three-Spined Stickleback EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

GASTEROSTEUS ACULEATUS

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS)									
			0	1	2	3	4					
4	control		30	30	30		29					
	1/100		30	30	29		28					
	1/50		30	30	30		28					

Data used in preparation of Table 5-17

BIOASSAY DATA

TYPE Continuous Flow OBSERVER Bill Moffett DURATION 4 - 8 days

SUBJECT ORGANISM DUNGENESS CRAB LARVAE EFFLUENT S. F. COMPOSITE WATER SOURCE FORT BAKER

CANCER MAGISTER ZOEA

EXPERIMENT NUMBER	RATIO OF EFFLUENT: WATER	VOLUME	SURVIVORS AT TIME INDICATED (IN DAYS) 0	1	2	3	4	5	6	7	8	
1	Control		30	29	28		25					
	1/50		30	29	26		25					
2	Control		30	30	29		27					
	1/50		24	23	22		17					
3	Control		250		214		210		60		17	
	1/100		250		213		205		50		25	
	1/50		250		241		237		29		0	
												Data used in preparat of Table 5-17

Blood Studies

A Summary of Results of an Experimental Study of Effects of Sewage on Blood of the Stickleback, *Gasterosteus aculeatus*

by Gretchen Kaplan

A SUMMARY OF RESULTS OF AN EXPERIMENTAL STUDY OF EFFECTS OF SEWAGE ON BLOOD OF THE STICKLEBACK, *GASTEROSTEUS ACULEATUS*

BY GRETCHEN KAPLAN

Using adapted mammalian procedures, the hematological response of *Gasterosteus aculeatus* to various concentrations of untreated domestic sewage was investigated over a period of 7 days exposure time. The normal hematological picture of this organism was first determined. The peripheral blood of the stickleback was found to contain erythrocytes with an average cytosome size of 10.7 x 6.5 micra and an average nuclear size of 4.1 x 2.5, lymphocytes averaging 6.2 micra in diameter, neutrophils average 10.5 x 8.8 micra, macrophages averaging 14.6 x 10.7 micra and thrombocytes averaging 4.2 micra in diameter. The mean erythrocyte count was found to be 3,544,000 cells per mm^3, the mean leucocyte count 28,857 and the mean thrombocyte count 62,000. The mean hematocrit was determined to be 37.0%. It was further noted that the hematocrit correlated significantly with the standard length (age).

Although there appeared to be an increase in the erythrocyte count due to keeping fish in sewage, the increase was not significant. Since the erythrocyte number or size was not significantly affected, it was expected that the hematocrit would not respond. This was found to be the case.

On the other hand, bacterial counts of sewage concentrations greater than 17% were found to increase the leucocyte count. Progressively greater concentrations resulted in progressively greater counts. There was a significant difference between the leucocyte counts at all levels or concentrations studied except between the control and 10% group. There was no statistically significant difference between the counts observed on various days, although a pattern seemed to develop. This pattern revealed peak leucocyte counts on the 4th and 5th days. Thereafter, there was a decrease in the number of leucocytes and by the seventh day normal or near normal values had been reached. The high and low peaks in the leucocyte count appeared 48 hours after the high and low peaks respectively in the bacteria counts in sewage. A significant correlation was found to exist between the bacteria count of sewage and the leucocyte count 48 hours later. The leucocyte count responded almost immediately; there were increased counts on the first day.

Neutrophils observed in the experimental groups were smaller and rounder than neutrophils of control groups. Furthermore, their nuclei were kidney shaped and not located as in control neutrophils. These facts indicate that the neutrophils in the experimental groups are actually myelocytes or immature neutrophils and that the hemopoietic organs are responding to the bacterial stress by sending neutrophils (immature) to the peripheral/blood where they can defend the organism against bacteria invasion. Neutrophilia is a known response to bacterial invasions in mammals.

Thrombocytes also respond to bacterial levels of different concentrations of sewage. The exact threshold for thrombocyte response was not determined, but it is lower than the 10% level of sewage concentration. At the 10% level, there was a significant decrease in the number of thrombocytes in the peripheral blood. Such a decrease has been observed in the blood of rainbow trout due to inflammation (Weinrab, 1958). However, at levels greater than 10%, there is an increase in the number of thrombocytes, and progressively greater concentrations result in progressively greater counts. The difference between the counts at all levels or concentration is significant.

Further, there is a significant difference between thrombocyte counts on various days except for days one and two. On the third day, there was a decrease in the number of thrombocytes below the levels of the first and second days. (This decrease was not back to a normal value.) This was accounted for by a depletion in the hemopoietic organs. On the fourth day, the thrombocyte count was at a peak. Thereafter, there was a decrease in the number of thrombocytes and by the 6th or 7th day normal or near normal values had been reached. The high and lows in the thrombocyte count appeared 48 hours after the high and low peaks respectively in bacteria counts in the sewage. A significant correlation was found to exist between the bacteria count of the sewage and the thrombocyte count 48 hours later. The thrombocyte count responded almost immediately; there were increased counts on the first day.

Further investigation should center around the thrombocyte. There are three main questions that need to be answered. At low levels of sewage, or what should now be interpreted as low counts of bacteria there is a decrease in the number of thrombocytes below normal values, but a higher bacteria counts their number increased progressively above normal. This reversal should be investigated. Second, why is the number of thrombocytes correlated with number of bacteria when these cells serve

no known bacterial defense function? Last, why do thrombocyte counts respond to lower levels of sewage than do leucocytes when leucocytes are the main element for defense against bacteria?

SECTION III

Ancillary Reports

Tidal Exchange at the Golden Gate

Denny S. Parker, Dan P. Norris and Austin Nelson,
October, 1971

TIDAL EXCHANGE AT THE GOLDEN GATE

Because of the complexities of bay and estuarine systems, sophisticated mathematical models are being employed to an increasing degree in water quality management planning. A myriad of inputs are required for these modeling efforts, and one of the most difficult phenomena to define is the exchange of bay and ocean waters which takes place due to tidal action at the mouth of an estuary. Not all of the water which ebbs from a bay is returned to it. Some is transported away by ocean currents and replaced by new ocean water. Tidal exchange ratio, simply stated, is that portion of the flooding tide which is ocean water entering the bay for the first time.

Tidal exchange can be a powerful flushing mechanism even when there is no net advection out of the bay. As a result, any water quality model which correctly models the seaward end of an estuary must make a proper allowance for tidal exchange. The present investigation rose out of the joint need of two agencies, the City and County of San Francisco and the State of California Department of Water Resources, to determine the tidal exchange ratio for San Francisco Bay. In 1969 San Francisco engaged the firm of Brown and Caldwell to conduct a study of Central San Francisco Bay and the adjacent Gulf of the Farallones, and to develop a program for marine disposal of the city's sewage effluent. One item of the study work program was the establishment of the tidal exchange ratio at the Golden Gate. At about the same time the State of California Water Resources Control Board contracted with the Department of Water Resources to determine the waste assimilative capability of San Francisco Bay using mathematical hydrodynamic and water quality models originally developed for the Bay Delta Water Quality Control Program (1). The Department of Water Resources recognized the need for a reliable value for tidal exchange to be used with the models.

Tidal exchange is a function of a number of characteristics that may be unique to any particular bay. These include offshore current conditions, the degree of stratification in the estuary, size and configuration of the estuary, and tidal conditions. The literature contains few reports of the determination of exchange ratio. Reinsch and Hardy (2) used orthophosphate balance and drogue release data to estimate tidal exchange ratio at Port Philip Bay, Australia, and arrived at an estimated range of 50 to 70 percent. Pritchard (3) concluded on the basis of the circulation pattern in Cheasapeake Bay that the tidal exchange ratio for Baltimore Harbor was about 20 percent.

One of the most interesting aspects of this tidal exchange investigation was the commendable degree of interagency cooperation achieved in the collection of the necessary oceanographic information. As the work program developed a number of agencies expressed interest in the program and offered to participate. Each of the two oceanographic cruises involved from 25 to 30 people representing eleven agencies. In addition to the two sponsoring agencies and their consultants, the field work included participating engineers, scientists and technicians from the San Francisco Regional Water Quality Control Board, U.S. Geological Survey, U.S. Corps of Engineers, San Francisco State College, Oregon State University, East Bay Municipal Utility District, and the City of Santa Cruz. Equipment was loaned by the Scripps Institute of Oceanography, and research vessels were provided by the U.S. Geological Survey and the State Department of Water Resources. The interest and participation of all agencies almost wholly without red tape,enabled an undertaking which would have been beyond the budgetary capability of one agency alone.

THEORY

The method employed in this investigation of tidal exchange requires the presence of a suitable tracer, which must originate exclusively or in significantly greater

concentrations in either the estuary or the ocean. It was postulated that if a suitable tracer could be found, field measurement of the tracer level on an ebb tide and a following flood tide, compared to a background level in the ocean, would serve to establish the tidal exchange ratio.

All water which passes through the Golden Gate on a flood tide consists of water which has been in the bay before (old water) and water which has not (new water). The tracer level in old water can be defined by measuring the level on the preceding ebb, and the tracer level in new water can be determined by measuring a background condition in the ocean. Measurement of tracer level on the flood tide will then serve to establish the fractions of old and new water in the flooding tide. The fraction of new water entering the bay on the flood tide is the tidal exchange ratio. Expressing this concept mathematically as a mass balance of tracer for the flood tide when broken into old and new components, and summed over time increments in the flood phase, yields:

$$\sum_{i=1}^{n} Q_{Fi} C_{Fi} \Delta T = \sum_{i=1}^{n} Q_{Ei} C_{Ei} \Delta T + \sum_{i=1}^{n} Q_{Oi} C_{O} \Delta T, \qquad (1)$$

Where:

ΔT = Time increment,

Q_{Fi} = Flood flow in time increment i,

C_{Fi} = Flood concentration in time increment i,

Q_{Ei} = Flow of returning bay (ebb) water in time increment i,

C_{Ei} = Tracer level of returning bay (ebb) water in time increment i,

Q_{Oi} = Flow of new water entering the bay in time increment i,

C_{O} = Tracer level of new water entering the bay on the flood tide, and

n = The number of time increments in the flood phase.

By definition, the tidal exchange ratio in time increment i is:

$$r_i = \frac{Q_{Oi}}{Q_{Fi}} \tag{2}$$

A flow balance also yields:

$$Q_{Ei} = Q_{Fi} - Q_{Oi}. \tag{3}$$

Substituting equations (2) and (3) into equation (1) yields:

$$\sum_{i=1}^{n} Q_{Fi} C_{Fi} \Delta T = \sum_{i=1}^{n} (1-r_i) C_{Ei} Q_{Fi} \Delta T + \sum_{i=1}^{n} r_i Q_{Fi} C_O \Delta T \tag{4}$$

Available information on the hydrodynamics of the Gulf of the Farallones did not allow assumption of a theoretical form for the distribution function for the tidal exchange ratio with time or flood volume, although tidal exchange data reported later do suggest that such a relationship might exist. For data analysis purposes, the tidal exchange ratio was assumed to be constant through the flood phase at a value $\overline{r}$. Further, it was assumed that water from preceding ebbs returns with a weighted average tracer level $\overline{C_E}$, defined by:

$$\overline{C}_E = \frac{\sum_{j=1}^{m} Q_{Ej} C_{Ej} \Delta T}{\sum_{j=i}^{m} Q_{Ej} \Delta T}, \tag{5}$$

where: Q_{Ej} = Ebb flow in time increment j of preceding ebb,

C_{Ej} = Ebb concentration in time increment j of preceding ebb,

ΔT = Time increment duration, and

m = The number of time increments in the ebb phase.

With these assumptions, equation (4) can be simplified to:

$$\frac{\sum_{i=1}^{n} Q_{Fi}C_{Fi}\Delta T}{\sum_{i=1}^{n} Q_{Fi}\Delta T} = (1-\bar{r})\bar{C}_E + \bar{r}C_O \qquad (6)$$

The expression on the left hand side of this equation is by definition the weighted average $\bar{C}_F$, because

$$\bar{C}_F = \frac{\sum_{i=1}^{n} Q_{Fi}C_{Fi}\Delta T}{\sum_{i=1}^{n} Q_{Fi}\Delta T} \qquad (7)$$

Substituting equation (6) into equation (5) yields with rearrangement:

$$\bar{r} = \frac{\bar{C}_F - \bar{C}_E}{C_O - \bar{C}_E} \qquad (8)$$

Equation (8) is the basic expression employed for data analysis. Significantly, flow terms have been eliminated from the expression. However, weighted average flood and ebb tracer levels must be determined by equations 5 and 7, which still contain flow terms. Nevertheless, flow measurements are not required, as the weighting of tracer levels can be accomplished either by using historic current data, as was done in this case, or by assuming a distribution of flow through the tidal phase. USC&GS current data collected in August of 1953 (4), were used to determine a flow distribution function by normalizing the volume of water passed in the flood phase with respect to time against the total volume passed in the phase. For the flood phase, for instance, the flow distribution function, F_i , is:

$$F_i = \frac{Q_{Fi}\Delta T}{\sum_{i=1}^{n} Q_{Fi}\Delta T}, \qquad (9)$$

Substituting equation (9) into equation (7) for average flood tracer level results in the form utilized for this study as:

$$\bar{C}_F = \sum_{i=1}^{n} F_i C_{Fi}, \qquad (10)$$

PROCEDURE

Once the measurement of tidal exchange had been determined to be theoretically feasible, a procedure had to be worked out which was compatible with the theoretical approach. A suitable tracer had to be identified, and basic decisions had to be made regarding the time, location, and method for data collection.

Tracer Selection

The only theoretical restrictions on tracer choice are that it be a conservative water quality constituent and that there be a significant difference between average ebb and flood concentrations. By examining Equation 8 it can be observed that the latter condition is assured if there is an adequate difference, between average ebb and background concentrations. As a practical matter, a suitable tracer must also occur naturally and must be precisely measurable by routine laboratory procedures.

In September of 1969 a tracer search was conducted with the assistance of the Sea Scout Ship Dauntless, a 54-ft. converted naval vessel. Starting at the San Francisco Bay Bridge at slack before flood, water samples were collected at about 5-mile intervals westward to Southeast Farallon Island, some 23 miles west of the Golden Gate. Each sample was analyzed for temperature, chlorides, pesticides, heavy metals, and ultraviolet absorption. Of the constituents examined, only temperature and chlorides showed any promise as tracers. Temperature of bay water was found to be 10 deg F higher than ocean water, and chlorides in bay water were up to 7 ppt lower than ocean water. The decision was made to conduct field measurements of tidal exchang using both temperature and chlorides, and then reject the tracer which showed the least uniform background levels in the ocean waters.

Time of Measurement

An implied assumption in the mass balances presented previously and in any conventional method of composite sample collection is that currents across the channel

cross section remain in phase with depth. In other words, reversal of flow must occur at approximately the same time at both the surface and at the bottom. Measurements taken in February, 1970 demonstrated that during periods of high fresh water outflow from the San Francisco Bay System there is marked current and density stratification at the Golden Gate. As a result, currents on the surface and at depth are severely out of phase. Analysis of current information taken by the U.S. Coast and Geodetic Survey during 1952 and 1953 (4), on the other hand, showed that while current velocities in the fall differ somewhat at surface and at depth, flow reversal occurs at approximately the same time for tides without diurnal inequality. Observations reported by Pearson, et al (5) demonstrate that the maximum difference in temperature between the bay and ocean occurs during September of each year. This is also the time when water clarity is the greatest and net seaward advective flow the smallest because of reduced fresh water flow. All factors therefore indicated that the field work should be performed during September.

Tides at the Golden Gate exhibit diurnal inequality; that is, each lunar day of 25 hours contains two high waters and two low waters of different heights. The amount of inequality varies from day to day, passing through a cycle from nearly equal tides to maximum inequality and back to equal tides twice in a lunar month of 28 days. Examination of US Coast and Geodetic Survey current data (4) for Central San Francisco Bay and the Gulf of the Farallones showed that unequal tides are more likely than equal tides to have currents out of phase with depth. A second major factor favoring observation on equal tides was the length of the sampling period. To obtain a mass balance of tracer, the tidal condition must be the same at the end of the observation period as at the start. For unequal tides this would require continuous observation over a complete 25-hour tidal cycle, while with equal tides the observation period need be only one ebb and the following flood, or 12 1/2 hours. The longer observation period would require twice as many people, larger boats, more sample analyses,

and a considerably greater cost. For both theoretical and practical reasons, therefore, the field work was scheduled for periods of equal tides. Two equal tidal conditions of different amplitudes, on September 2-3, and September 16, 1970, were selecte for tidal exchange measurements. Tidal conditions for both cruises are shown in Fig. 1. Current is offset slightly from stage at the Golden Gate, and the indicated periods of measurement span from about an hour before high slack to an hour after the following high slack.

Location for Measurement

For use in water quality modeling of the Central Bay, it would be most desirable if the determination of tidal exchange could be made on a survey line across the bayward end of the Golden Gate. Several practical factors, however, strongly favored the establishment of a survey line across the seaward end. (Fig. 2). These were:

1. The bottom profile of the cross section at the seaward end of the Golden Gate is more uniform, and there are indications that the current velocity is fairly uniform across the section.

2. The maximum depth at the seaward end is about 130 ft., which was within the depth range of the available monitering equipment.

3. A USC&GS current station near the survey line provided a good basis for weighting tracer levels for flow.

4. A portion of the tracer sampling had to be done at night. Point Bonita and Mile Rock, the two lighthouses which anchor the ends of the survey line, provided excellent visual and radar fixes on the position of the tracer sampling stations.

5. The bottom was clear at the seaward end of the Gate, while the charts show a wreck at the bayward end which represented a possible hazard to the sampling gear.

The tidal exchange theory indicates that tidal exchange ratio can be determined at any point where representative tracer levels can be measured on an ebb tide and on the following flood. Because the information would be directly pertinent to the

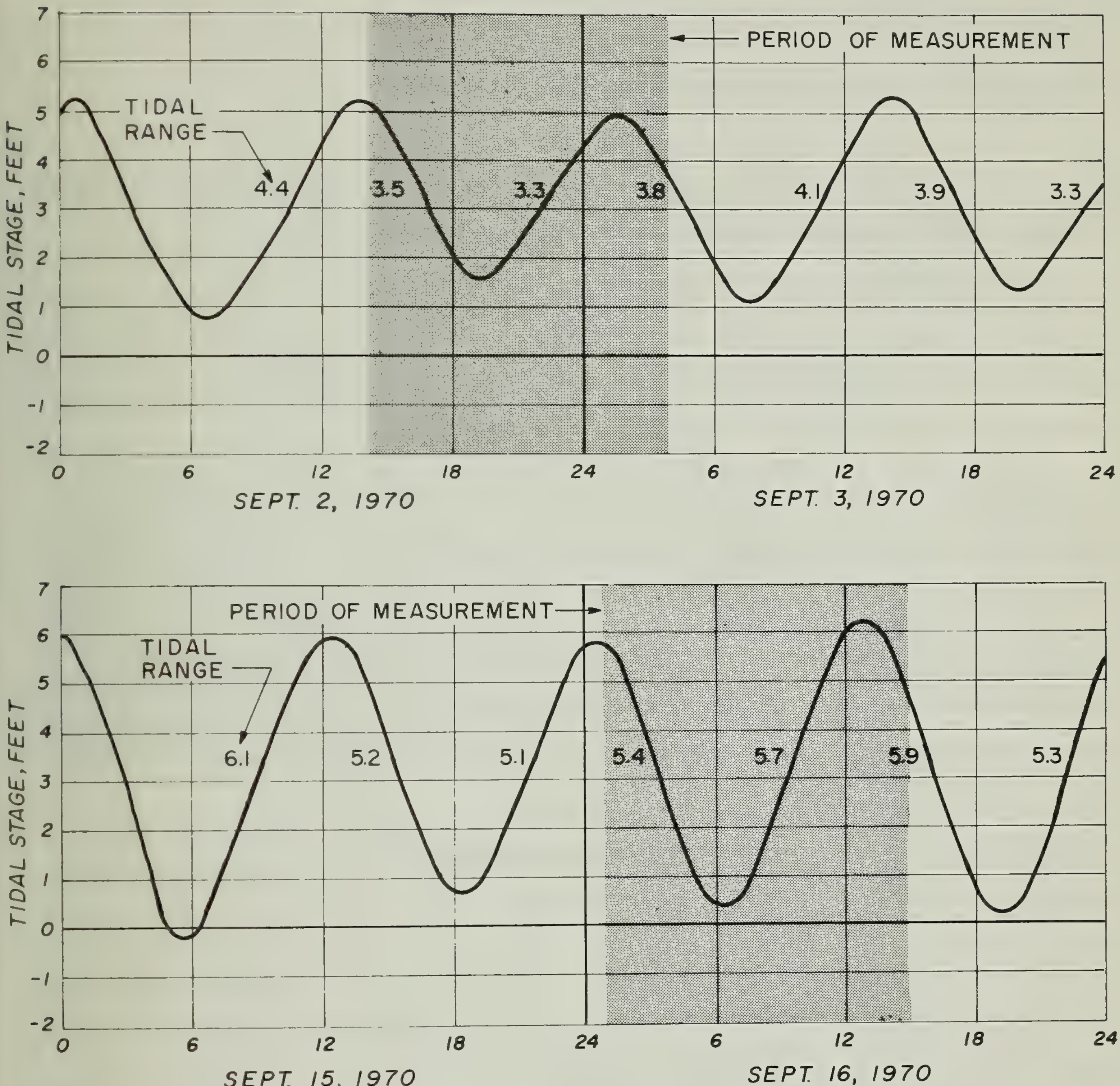

Fig. 1 **Tidal Stage at the Golden Gate During Tidal Exchange Measurements**

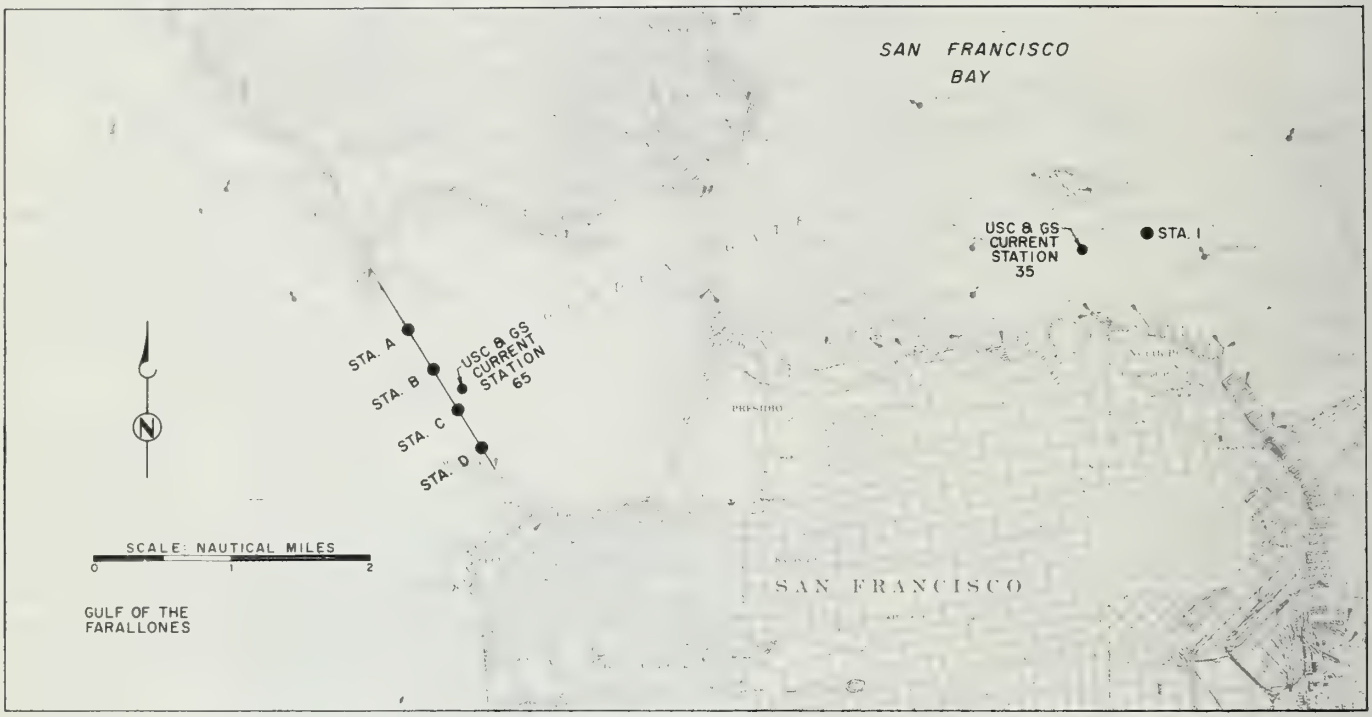

Fig. 2

Water Column Sampling Stations

effluent disposal study for the City of San Francisco, an attempt was also made to measure tidal exchange through Alcatraz Channel. The actual location selected for tracer sampling (Fig. 2, Station 1) was slightly offset from the center of the channel, a compromise felt necessary because tracer samples had to be collected at night by an anchored small boat. The center of the channel is heavly traveled by shipping and was considered unsafe.

Method of Data Collection

The interagency work program specified measurement of tracer levels at three locations: the mouth of the Golden Gate, Alcatraz Channel in San Francisco Bay, and the Gulf of the Farallones at a distance far enough from the Golden Gate to represent background conditions. Each of the sampling locations used varied methods and equipment.

Golden Gate. The sampling procedure at the Golden Gate was considered most critical to the success of the project, and special care was given to its implementation. Successful conduct of the program required continuous monitoring of tracer for a full tidal cycle, and to insure success the program was planned with a primary and a backup tracer, a backup system of measurement for each tracer, and backup equipment for each measurement system. The basic measurement systems were very simple, which provided insurance for the successful completion of the work.

The primary tracer was chlorides, with temperature selected as backup because it was assumed that temperature was less likely to show a representative background level. This assumption proved correct. A small submersible well pump of the type sold by the major catalogue stores was equipped with 200 ft of submersible electric cable and 3/4-in. garden hose. The pump was lowered by electric winch until a depth sensing element indicated the same depth as the boat's fathometer. The pump and winch were then started at the same time and the pump drawn to the surface at a constant rate. The pump discharge was directed into a 20-gal plastic garbage can, with allowance made for the timed passage of sample through the hose. The sample thus collected

was a representative sample of the entire water column at the point of sampling. The contents of the garbage can were stirred, the temperature was measured, and two samples were bottled for chloride anaysis by a modified Mohr titration method (6). Two titrations were performed on each sample. The backup system was a Martek temperature-conductivity sensing system, which together with the depth probe, was lowered with the pump. A spare Martek unit and a spare pump were carried aboard the boat. Fortunately, the primary equipment worked without any problem on both cruises.

The boat used for sampling at the Golden Gate was the R/V Amigo, a 50-ft. charter oceanographic research vessel. With four stations as shown on Fig. 2, it was assumed that the Amigo could sample at each station once each hour. As soon as a routine was established, this assumption proved very nearly correct. Each station repr sents almost the same fraction of the cross sectional area of the mouth of the Golden Gate, the distribution being 23 percent for Station A, 26 percent for Stations B and C, and 25 percent for Station D.

Each sample was taken while the boat was drifting. The direction of drift was observed at approximately 15-min intervals, which gave a good fix on the actual time of reversal of surface flow. Throughout the period of measurement the 5/32-in. equipment wire hung nearly vertical even when the pump was near the bottom. This indicated that currents were not markedly different at the surface and at depth. In measurement taken during the winter period of strongly stratified flow, wire angles of 45 deg from vertical have been observed.

Alcatraz Channel. The sampling station in Alcatraz Channel was occupied by the Beowulf, a 25-ft water quality monitoring boat operated by the Department of Water Resources. The Beowulf is equipped with a submersible pumping system which can be raised and lowered by winch, and the sampling procedure was therefore similar to that used aboard the Amigo. Since the Beowulf was anchored, however, samples were collecte every half-hour instead of every hour.

Gulf of the Farallones. Data to establish background tracer levels in the new ocean water were collected aboard the US Geological Survey boat Polaris, which sampled

a number of ocean stations (Fig. 3) during the 12-hour period when the tidal exchange sampling was in progress. Since the measurements were made during September, when the California Current flows southerly along the Central California coast, preference was given to ocean stations lying north of the mouth of the Golden Gate. In any event, no substantial difference was observed between the chloride levels to the north and to the south of the Golden Gate.

Temperature and chloride levels were sampled by means of Nansen bottles borrowed from Scripps Institute of Oceanography. Samples were collected at depth intervals of 25 to 50 ft., depending on water depth at the station sampled. Graphs of water column temperature and chloride for each station are included in appendix III. Chloride levels were uniform from surface to bottom and from station to station within very narrow limits at the stations used for background analysis. Temperature, on the other hand, showed such wide variation from surface to bottom that it was judged unreliable as a tracer. All calculations of tidal exchange were therefore based on chloride levels as measured by titration. Background chloride levels for each of the tidal exchange measurements are presented in Table 1. The chloride level for new water was established at 19, 119 mg/l for the September 2 and 3 tidal exchange measurement and 19, 146 mg/l for the September 16 measurement.

DATA ANALYSIS

Field measurements were used to compute the tidal exchange at each station at the mouth of the Golden Gate. The computed values were tested for sensitivity to various possible sources of error, and a composite value for tidal exchange was determined for each of the tidal conditions measured. Using a similar procedure, the amount of new water flowing past the Alcatraz Channel station on a flood tide was also computed.

Tidal Exchange at the Golden Gate

Chlorides from the water column composites taken along the survey line at the Golden Gate are portrayed in Figs. 4 and 5. Evidence of new water crossing the survey

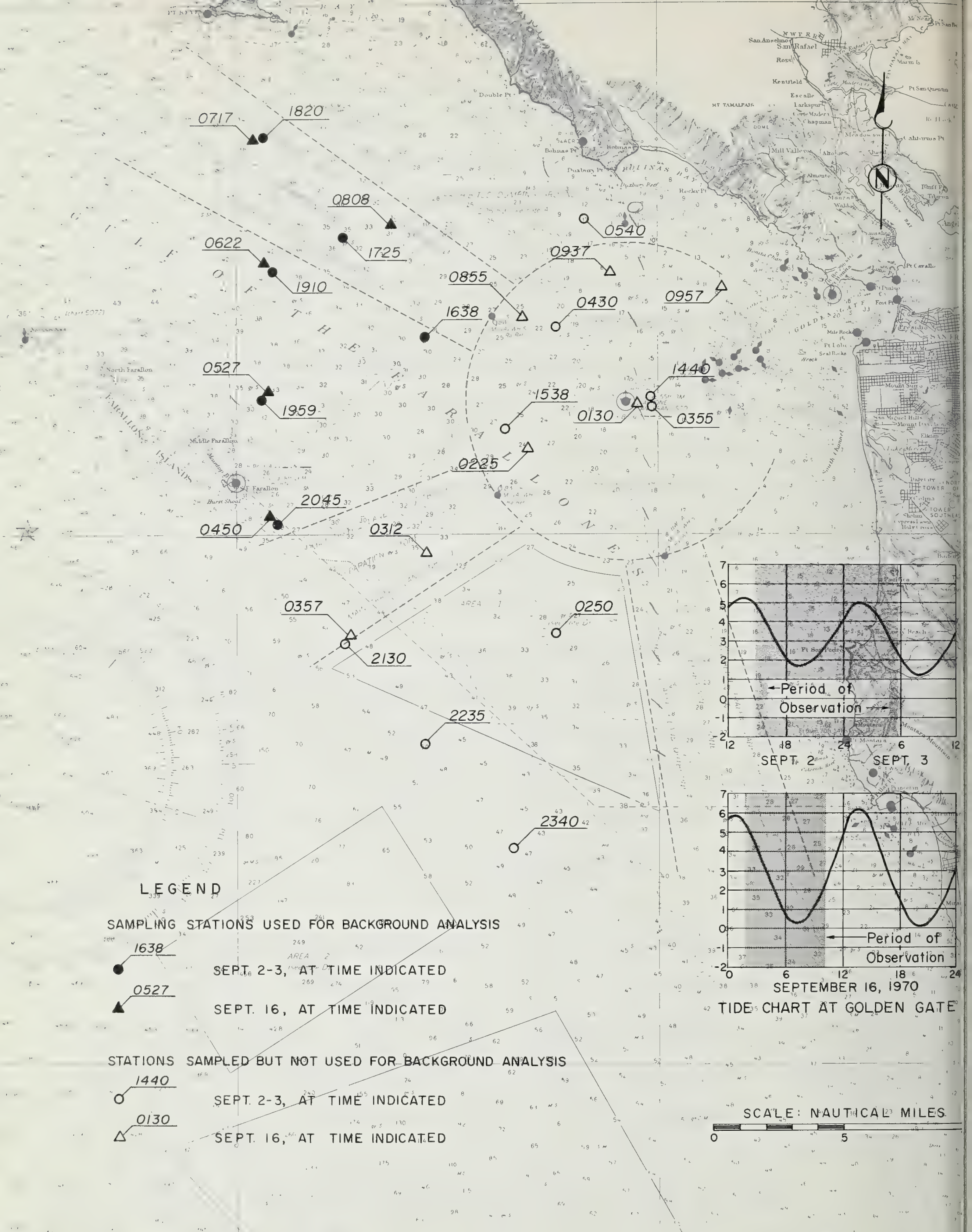

Fig. 3

Ocean Sampling Stations for Tidal Exchange Measurements, September, 1970

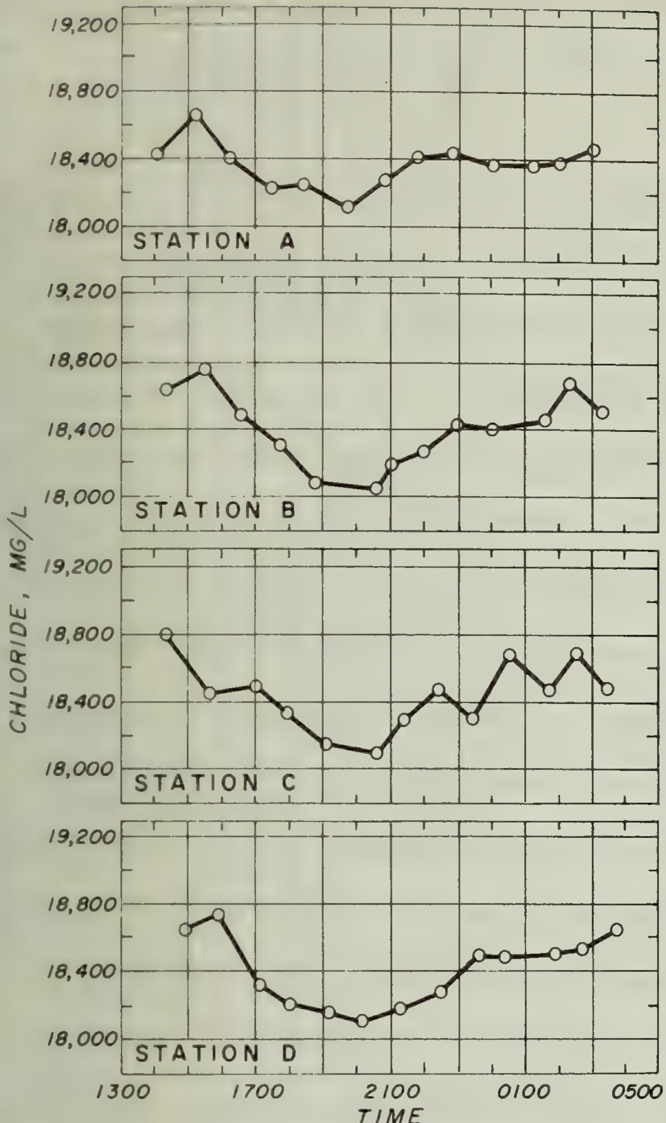

Fig. 4 Chlorides Measured on the Survey Line on September 2-3, 1970

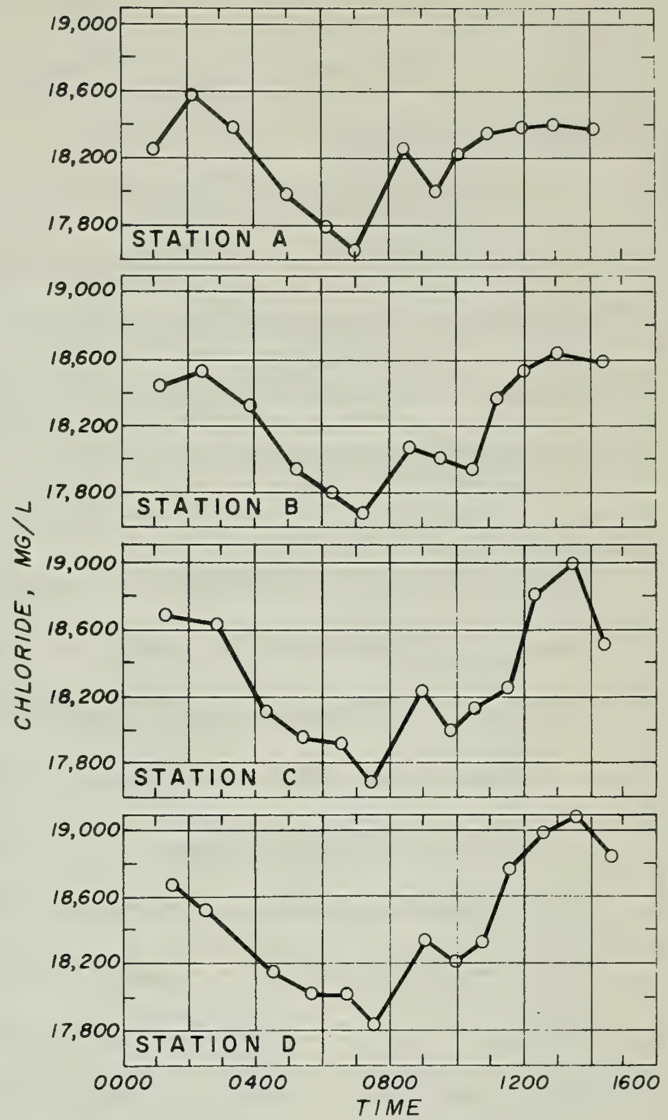

Fig. 5 Chlorides Measured on the Survey Line on September 16, 1970

Table 1 Average Chloride Concentration for Water Column Samples of Ocean Water

Cruise of September 2 and 3, 1970			Cruise of September 16, 1970		
Date	Time[a] (station)	Chlorides mg/l	Date	Time[a] (station)	Chlorides mg/l
Sept 2	1440	19,075	Sept 16	0130	19,113
	1538	19,156		0225	19,159
	1638	19,150		0312	19,242
	1725	19,111		0357	19,231
	1820	19,155		0450	19,171
	1910	19,099		0527	19,203
	1959	19,110		0622	19,203
	2045	19,080		0717	19,060
	2130	19,126		0808	19,095
	2235	19,109		0855	19,135
	2340	19,146		0937	18,977
	0250	19,130		0957	18,781
				1753	18,735
Sept 3	0355	19,061			
	0430	19,154			
	0504	19,039			

[a]See Figure 3.

line is apparent from the fact that chloride levels are higher in the flood period than in the ebb period. This is especially noticeable in Fig. 5, for the tide of greater amplitude.

The chloride peaks and dips in evidence in the early portion of the flood phase in Figs. 4 and 5 are attributed to the unique pattern of water circulation in the Gulf of the Farallones near the mouth of the Golden Gate. In other oceanographic studies (7) conducted for the City of San Francisco, it was found that the ebb tide flows strongly westward, while reversal occurs first from the north and south near shore. During the initial part of the flood, therefore, flood waters come from the north and south along the coast bearing a relatively high percentage of new ocean water. This explains the early chloride peaks observed in the figures. Later, flow reverses from the west and dilutes the effect of the waters coming from the north and south. This pattern of water movement is shown diagramatically in Fig. 6.

Composite Tidal Exchange. A Fortran-IV computer program was developed to perform the data analyses. The program accomplished the following tasks: (1) conversion of all measurement times to decimal hours with a common zero, (2) computation of average ebb and flood tracer concentrations at each station, employing historic current measurements and (3) computation of tidal exchange ratio at each station and the composite tidal exchange ratio for the Golden Gate.

Computed values for the tidal exchange ration at each station at the mouth of the Golden Gate are shown in Table 2. As the figures indicate, the amount of new water entering the bay was not uniformly distributed across the gate, and the distribution varied with tidal stage. Oceanographic studies of mass water movement around the mouth of the Golden Gate produced the independent observation that the distribution of new water entering the gate would be non-uniform.

Composite values for tidal exchange are shown in Table 3 for each of the two cruises and for several alternative slack water times. The exchange ratio was calculated for both predicted and observed slack water times. Since the observed and

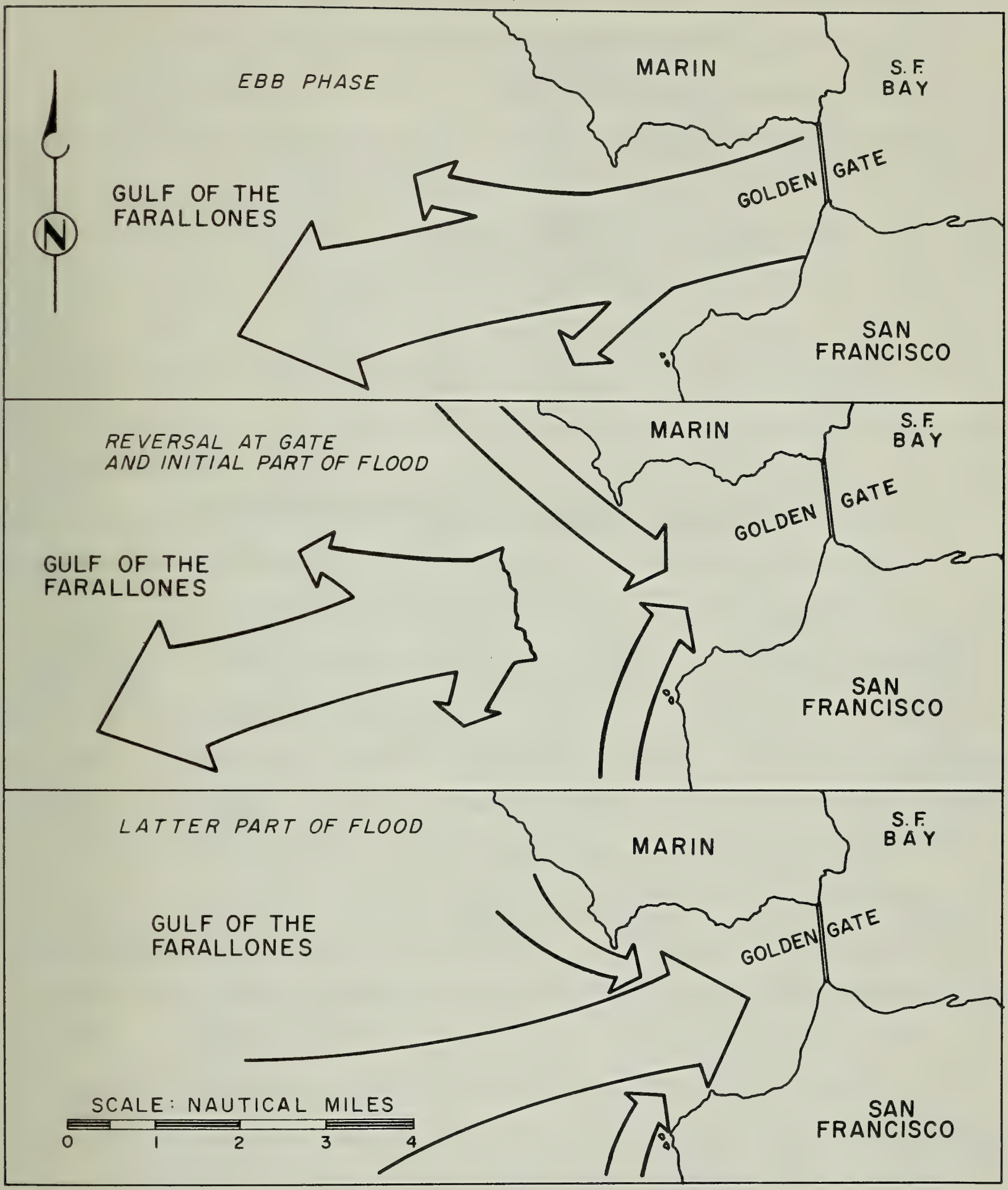

Fig. 6 Current Patterns at the Golden Gate

Table 2 Tidal Exchange at Each Station

Station	$\bar{C}_E$, mg/l	$\bar{C}_F$, mg/l	$\bar{r}$, percent
Cruise of September 2 and 3, 1970			
A	18,310	18,407	12
B	18,324	18,459	17
C	18,328	18,503	22
D	18,312	18,445	16.5
Cruise of September 16, 1970			
A	18,025	18,298	24
B	18,021	18,334	28
C	18,079	18,383	28
D	18,120	18,640	51

Table 3 Comparison of Computed Tidal Exchange Values with Alternative Slack Water Times at the Golden Gate

Slack water estimation procedure	Time of high water slack	Time of low water slack	Time of second high water slack	$\bar{C}_E$, mg/l	$\bar{C}_F$, mg/l	$\bar{r}$[b], tidal exchange ratio, percent
Cruise of September 2 and 3, 1970						
Predicted C&GS values	1458	2115	0309	18,319	18,455	17.1
Corrected C&GS values[a]	1504	2109	0315	18,309	18,453	17.9
Observed current slacks[c]	1517	2107	0251	18,299	18,447	18.0
Cruise of September 16, 1970						
Predicted C&GS values	0209	0827	1421	18,062	18,414	32
Corrected C&GS values[a]	0215	0821	1427	18,067	18,405	31
Observed current slacks	0215	0835	1350	18,067	18,404	31
Corrected observed current slacks[a]	0219	0831	1443	18,053	18,448	36

[a] Corrected to equalize flood and ebb duration over a full tidal cycle.

[b] Composite value for four stations using historic C&GS current data for weighting.

[c] Not corrected, as observed flood duration nearly equals ebb duration.

predicted values were for surface or near-surface conditions, it was considered possible that current reversals at depth were slightly out of phase with surface reversals. Exchange ratio was therefore also calculated using slack water times corrected for the assumption that under equal tide conditions the total ebb duration must nearly equal the total flood duration.

Based upon the several slack water time estimates, the tidal exchange ratio at the Golden Gate was 17 to 18 percent for the first cruise and 31 to 36 percent for the second cruise.

Sensitivity Analyses. The various parameters in the computation procedure which influence the tidal exchange ratio are: (1) the measured tracer values, (2) the ebb and flood flow distribution function, and (3) the estimated slack water times. The sensitivity of the computed exchange ratio to arbitrary variation of the latter two parameters was investigated.

Substitution of a sinusoid or straight line (F_i = constant) flow distribution function for the historic current values had only a small effect on the computed tidal exchange ratio (Table 4), indicating that the exchange ratio is not highly sensitive to the assumption of a flow distribution function. To test sensitivity with respect to slack water time, the predicted slack water times were arbitrarily shifted by one-half hour individually forward or backward in time while holding the other slack water times at their predicted values. As would be expected, the computed tidal exchange ratio (Table 5 and 6) is sensitive to arbitrary variation in the slack water times. In essence, movement of the slack water time has changed the weighting applied to the data points.

Average Tidal Exchange. This study was undertaken primarily to define a boundary condition for mathematical water quality models which are used for waste management planning. Such models typically employ average tidal conditions for water quality simulations. Since quality constituent concentrations in a bay or estuary are a cum-

Table 4 Sensitivity of Computed Tidal Exchange to Normalization Function F

Flow distribution function[a]	Cruise of Sept 2 and 3, 1970			Cruise of Sept 15 and 16, 1970		
	$\bar{C}_E$, mg/l	$\bar{C}_F$, mg/l	$\bar{r}$, percent	$\bar{C}_E$, mg/l	$\bar{C}_F$, mg/l	$\bar{r}$, percent
Historic current	18,319	18,455	17.1	18,062	12,414	32
Sinuosoidal Distribution	18,295	18,457	19.7	18,026	18,425	36
Straight Line (F_i = constant)	18,458	18,458	16.7	18,053	18,437	35

[a]Using predicted C&GS current slacks.

Table 5 Sensitivity of Computed Tidal Exchange to Shifts in Current Slack Times of One-Half Hour for Cruise of September 2-3, 1970

Shift in slack position[a] \ Slack water	First high water slack	Low water slack	Second high water slack
Earlier than predicted	13	15	17
Later than predicted	21	21	19

[a]Indicated shifts are for the change of only the slack water time indicated while holding other slacks at the predicted C&GS slack water times; historic current data employed for low distribution; $\bar{r}$ = 17 for predicted C&GS slack time.

Table 6 Sensitivity of Computed Tidal Exchange to Shifts in Current Salck Times of One-Half Hour for Cruise of September 15-16, 1970

Shift in slack position[a] \ Slack water	High water slack	Low water slack	Second high water slack
Earlier than predicted	26	24	29
Later than predicted	32	38	36

[a]Indicated shifts are for the change of only the slackwater time indicated while holding other slacks at the predicted C&GS slackwater times; historic current data employed for flow distribution, $\bar{r}$ = 32 for predicted C&GS slack time.

ulative function of a succession of tidal conditions, an average tidal exchange ratio is an important factor in water quality modeling studies.

Tidal exchange was found to increase with tidal range (Fig. 7). Since one of the factors affecting tidal exchange is the volume of water drawn into the bay on a flood tide, it is logical to expect a larger fraction of new water as the volume passed increases. The relationship is shown graphically in Fig. 7, where measured tidal exchange ratio is plotted against flood tide range. The origin of the curve is treated as a data point, since the exchange ratio must approach zero as the tidal amplitude approaches zero. From Fig. 7, the tidal exchange ratio at the Golden Gate, expressed as a percentage of the water passing the Gate on a flood tide, was determined to be 5.5 times the flood tide range in feet. Applying the tidal exchange equation to the mean tidal amplitude of 4.1 ft. (7) gives a mean tidal exchange ratio of 23 percent. A better measure of mean tidal exchange is to recognize that the tidal volume transfered in a tidal phase ("the tidal prism") also increases with tidal stage, increasing the volume of exchanged waters (8). Considering this effect the mean tidal exchange is conservatively estimated to be 24 percent.

It must be remembered that the curve in Fig. 7 is valid only for a condition of no flow stratification. The sampling and analytical procedures presume that currents were in phase with depth throughout the period of measurement. A review of current data for the Golden Gate area shows that the assumed condition is approached during dry weather conditions of minimum fresh water inflow for tides with little diurnal inequality. For tides with diurnal inequalities, there is some stratification of flow, which results in a net seaward movement of the surface layer and a net bayward movement of the bottom layer even during dry weather. Stratification of flow during tides with diurnal inequalities increases tidal exchange by bringing more new ocean water in with the bottom layer and moving more bay water out in the top layer than with tides without diurnal inequalities. The data points in Fig. 7 were obtained for equal tide conditions, and it is a conservative assumption to extend these data to tides with diurnal inequality in stage. Since the average San

Table 7 Comparison of Computed Tidal Exchange with Alternative Slack Water Times at Station 1

Slack water estimation procedure	Time of high water slack	Time of low water slack	Time of second high water slack	$\overline{C}_E$, mg/l	$\overline{C}_F$, mg/l	$\overline{r}$, Tidal exchange ratio, percent
Predicted C&GS values	0204	0822	1416	17,450	17,869	25
Corrected C&GS values[a]	0207	·0819	1433	17,443	17,885	26
Observed current slacks	0207	0804	1420	17,465	17,835	22
Corrected observed current slacks[a]	0154	0806	1418	17,491	17,836	21

[a] Corrected to equalize ebb and flood duration over a full tidal cycle.

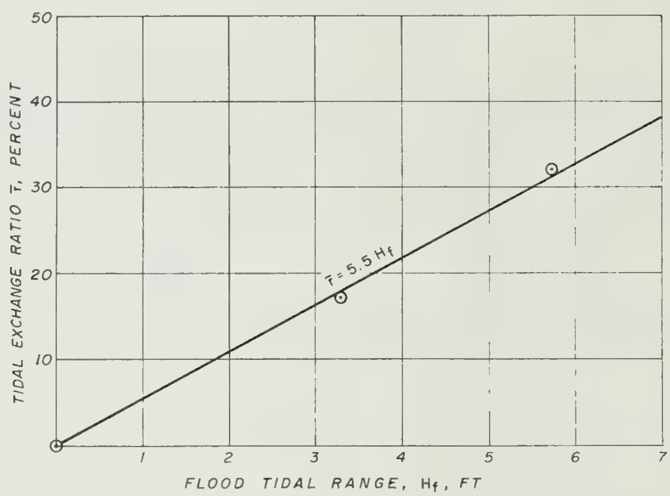

Fig. 7 Tidal Exchange Ratio vs Flood Tide Range for Dry Weather Conditions

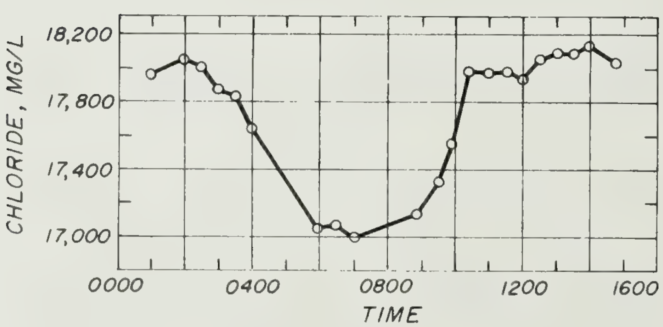

Fig. 8 Chlorides Measured at Station 1 on September 16, 1970

Francisco Bay tide has diurnal inequalities and therefore some flow stratification, the computed mean value is low by an indeterminate amount.

Tidal Exchange in Alcatraz Channel

The tidal exchange taking place within the bay at a station located between Blossom Rock and Alcatraz (Sta. 1, Fig. 2) was also of interest because it is the location of a prospective deep water outfall for the City of San Francisco.

The basic question asked was the same -- what is the fraction of new ocean water passing over station No. 1 on a flood tide? The water passing station No. 1 on the flood tide originates from three sources: (1) bay water which has previously passed the region near station No. 1, (2) other bay waters, and (3) new ocean water. It appears to be a conservative assumption to aggregate south bay and north bay sources into the terms Q_E and C_E; consequently the computed value of $\bar{r}$ will represent only new ocean water. "New" bay water will also pass Blossom Rock on a flood tide but this ratio cannot be computed by the present procedure.

Sufficient information was obtained only on the second cruise to allow computation of the exchange ratio. Measured chloride concentrations are presented in Fig. 8. Computed values of $\bar{r}$ are indicated in Table 7 for the several slack water time estimates. Historic current data for a point close to station 1 collected by the USC&GS on August 26 and 27, 1953 were used to develop the flow distribution function utilized in the computation. Based on this analysis, tidal exchange was between 21 and 26 percent on September 16, 1970. Corresponding value for tidal exchange at the Golden Gate on the same date was 31 to 36 percent.

APPLICATION OF RESULTS

In recent years several mathematical models have been developed to describe the water quality characteristics of San Francisco Bay. The validity of any such model for use in waste management studies depends in part on the use of a representative value for new water entering the bay through the Golden Gate as a result of

tidal exchange. Tidal exchange was measured at the mouth of the Golden Gate under dry weather conditions. The amount of new water entering the bay was found, as expected, to vary with tidal amplitude. A reasonable and conservative value for tidal exchange in dry weather for use in water quality models is 24 percent.

It should be emphasized that the tidal exchange curve in Fig. 7 can be considered to represent the lowest tidal exchange values occuring in a year. During periods of high delta outflow, density stratification is enhanced and a net seaward flow occurs in surface water layers, while a net flow up the Bay occurs in bottom water layers. Since bottom water movement increases the entry of new ocean water into the bay and the surface water layer increases the exit of bay waters, tidal exchange is increased in such periods. Thus, there is justification for modifying the tidal exchange ratio upwards during periods of high density stratification. Although there have been no actual field measurements of the exchange ratio in such periods, it is the opinion of the authors based on other oceanographic work that the tidal exchange ratio may be higher than 80 percent under conditions of maximum stratification.

Field measurements of tidal exchange during wet weather will require mass balance and flow balances similar to those utilized in the present study, but will have to deal with the stratified layering of flow. As a consequence, vertical current profiles will be required concurrently with tracer sampling at intervals with depth. The magnitude of labor and equipment investment necessary for such an effort will be beyond the resources of most agencies. There are at presnt no dynamic stratified flow models of San Francisco Bay to accept as inputs the results of such measurements.

SUMMARY AND CONCLUSIONS

A new method for measurement of tidal exchange was developed and applied to San Francisco Bay at the Golden Gate. The method is applicable to any estuary where density stratification is slight and a suitable tracer exists. In this case chlorides were used as the tracer. The measurement was accomplished by measuring the tracer

level of "old" bay water as it ebbed across the mouth of the Bay. The tracer level for "new" water was established from background ocean conditions. The combined old and new water tracer level was then measured on a succeeding flood. From these three tracer levels, the tidal exchange ratio can be determined.

An exact description of the flow through the bay-ocean interface is not required. However, a flow distribution function must be employed and the time of current reversal (slack water) must be determined with reasonable accuracy.

Tidal exchange at the Golden Gate during the dry weather-low inflow period of measurement was found to vary with tidal conditions and to correlate with flood tide range. In other words, tidal exchange can be expected to vary on a daily basis. However, water quality in San Francisco Bay will represent the effects of many successive tidal conditions. Hence, it is reasonable to employ the average value of 24 percent determined in this study.

During periods of strongly stratified flow the tidal exchange ratio will be higher, since the flow of new water into the Bay is enhanced by stratification.

APPENDIX I SYMBOLS

C_{Ei}	Tracer level of returning bay (ebb) water in time increment i
C_{Ej}	Ebb concentration in time increment j of preceding ebb
$\bar{C}_E$	Weighted average ebb tracer concentration
C_{Fi}	Flood concentration in time increment i
$\bar{C}_F$	Weighted average flood tracer concentration
C_O	Tracer level of new (ocean) water entering the bay on a flood tide
i	Time increment index in flood phase
F_i	Flow distribution function
j	Time increment index in ebb phase
n	Number of time increments in the flood phase
m	Number of time increments in the ebb phase
Q_{Fi}	Flood flow in time increment i
Q_{Ei}	Flow of returning bay (ebb) water in time increment i
Q_{Ej}	Ebb flow in time increment of preceding ebb
r_i	Tidal exchange ratio in time increment i
$\bar{r}$	Average tidal exchange ratio
ΔT	Time increment duration

APPENDIX II - REFERENCES

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5. Pearson, E.A. and Selleck, R.E., "A Comprehensive Study of San Francisco Bay - Fourth Annual Report."

6. Strickland, J.D.A. and T.R. Parsons, "A Practical Handbook of Seawater Analysis," Fisheries Research Board of Canada, pp. 17-19, 1968.

7. U.S. Coast and Geodetic Survey," Tidal Current Tables - 1970, Pacific Coast of North America and Asia," June, 1969.

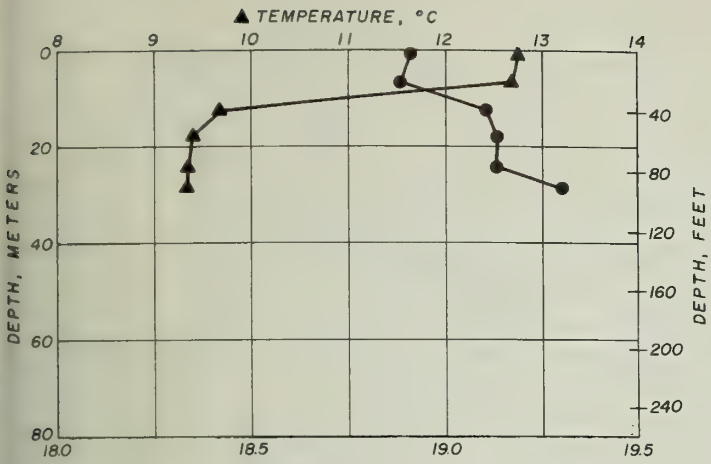
8. State of Calif., Department of Water Resources, "Salinity Incursion and Water Resources," Appendix to Bulletin No. 76, April, 1962.

APPENDIX III

Graphs of Water Column

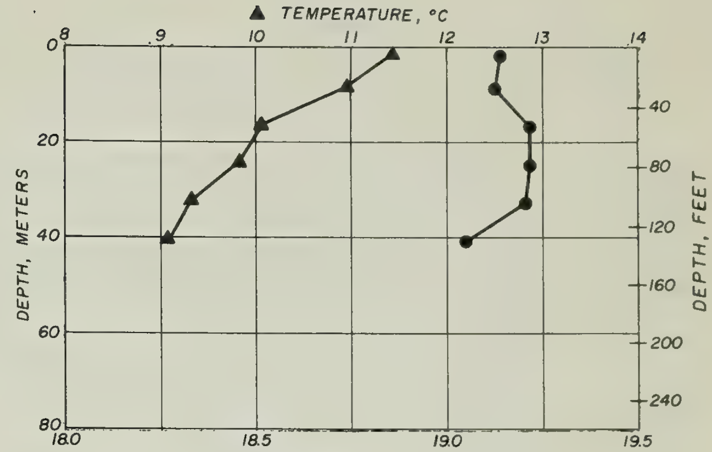
Temperature & Chloride.

Gulf of the Farallones



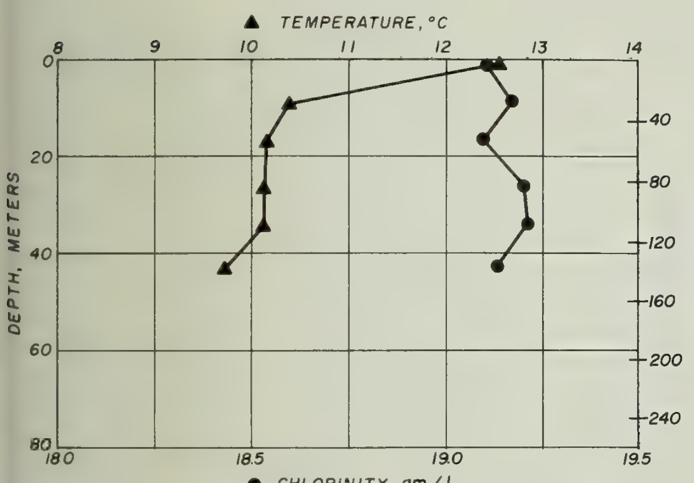
DATE 9/2/70 TIME 1440

DEPTH, M. 28 REF. FIG. 3



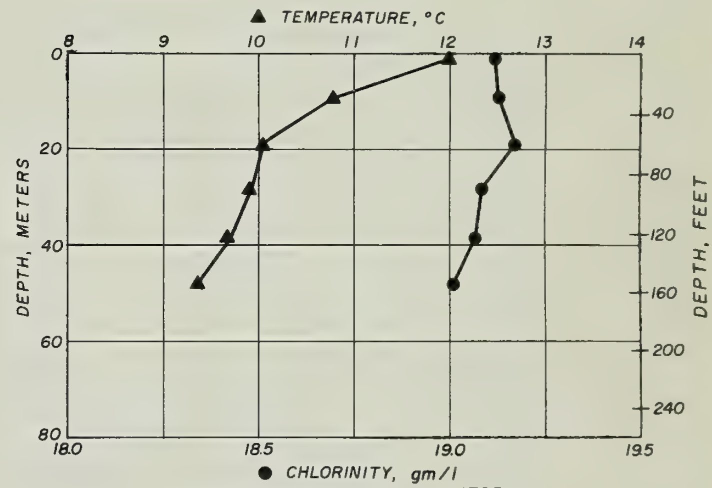
DATE 9/2/70 TIME 1538

DEPTH, M. 44 REF. FIG. 3



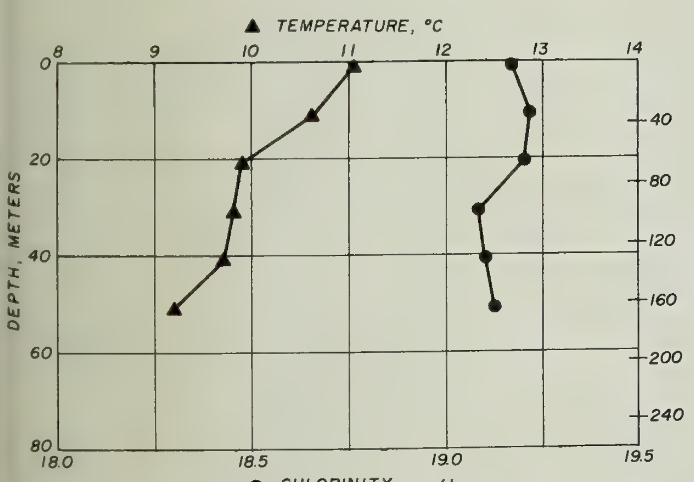
DATE 9/2/70 TIME 1638

DEPTH, M. 46 REF. FIG. 3



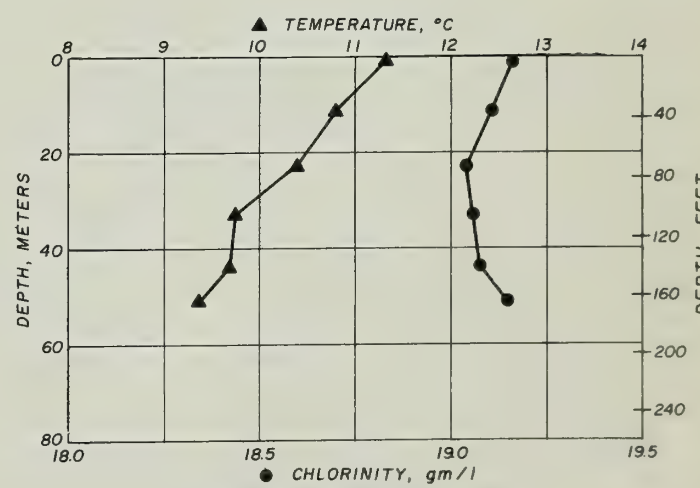
DATE 9/2/70 TIME 1725

DEPTH, M. 52 REF. FIG. 3



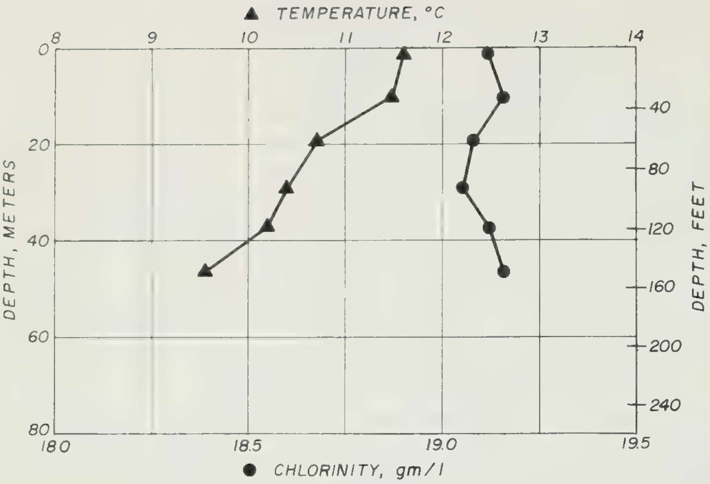
DATE 9/2/70 TIME 1820

DEPTH, M. 52 REF. FIG. 3

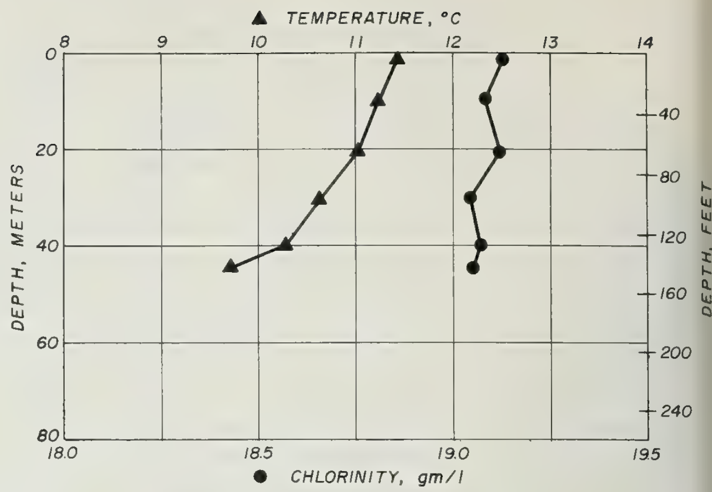


DATE 9/2/70 TIME 1910

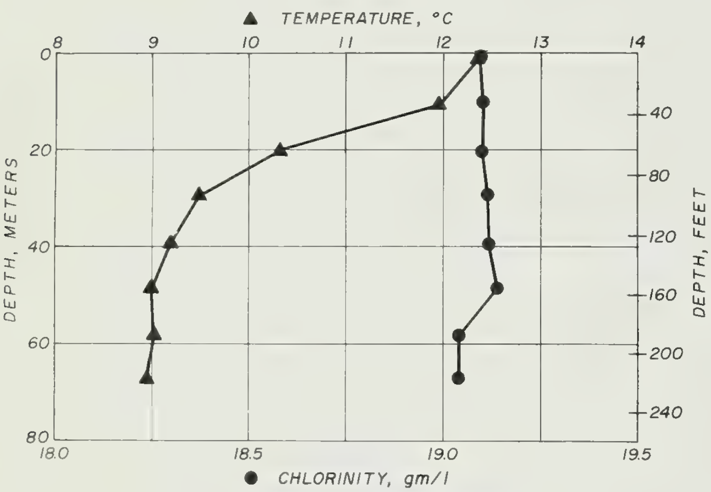
DEPTH, M. 61 REF. FIG. 3



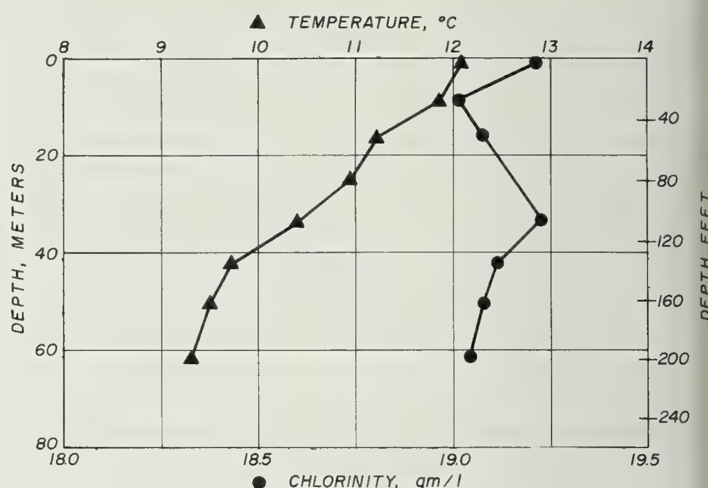
DATE 9/2/70 TIME 1959
DEPTH, M. 49 REF. FIG. 3



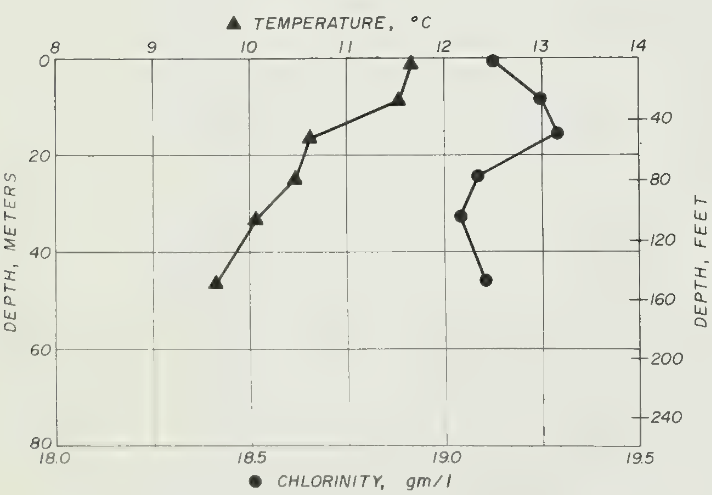
DATE 9/2/70 TIME 2045
DEPTH, M. 48 REF. FIG. 3



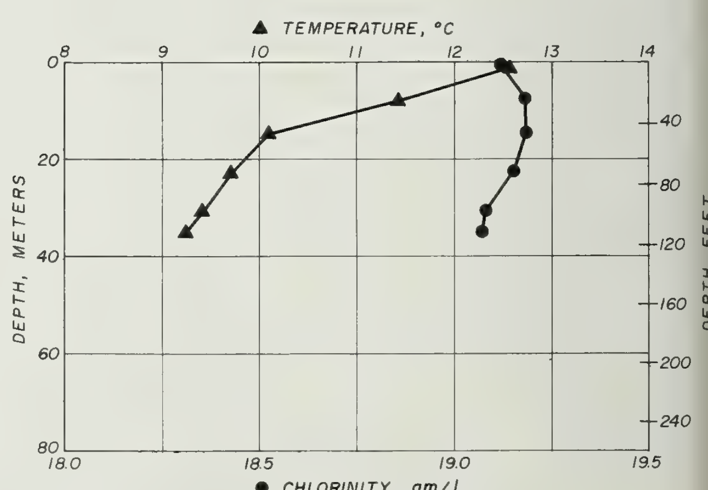
DATE 9/2/70 TIME 2130
DEPTH, M. 73 REF. FIG. 3



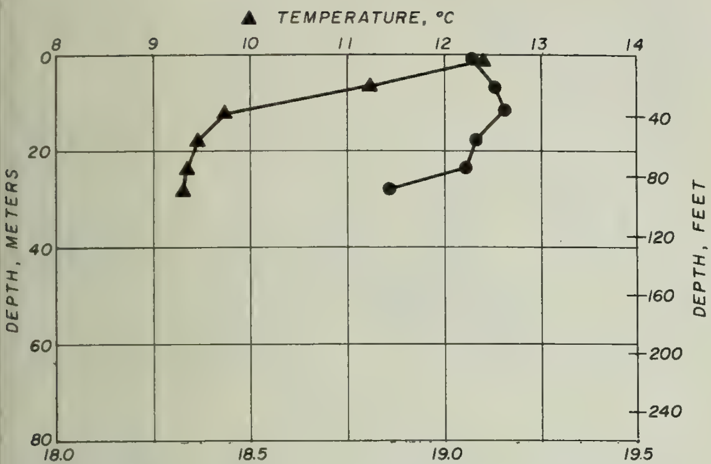
DATE 9/2/70 TIME 2235
DEPTH, M. 67 REF. FIG. 3



DATE 9/2/70 TIME 2340
DEPTH, M. 48 REF. FIG. 3

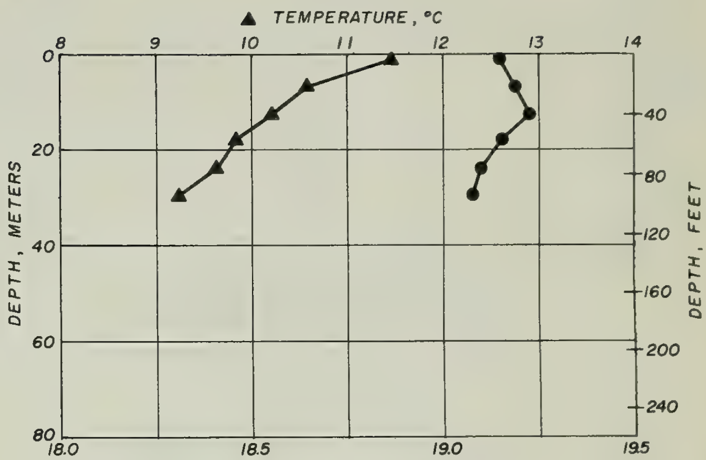


DATE 9/3/70 TIME 0250
DEPTH, M. 36 REF. FIG. 3



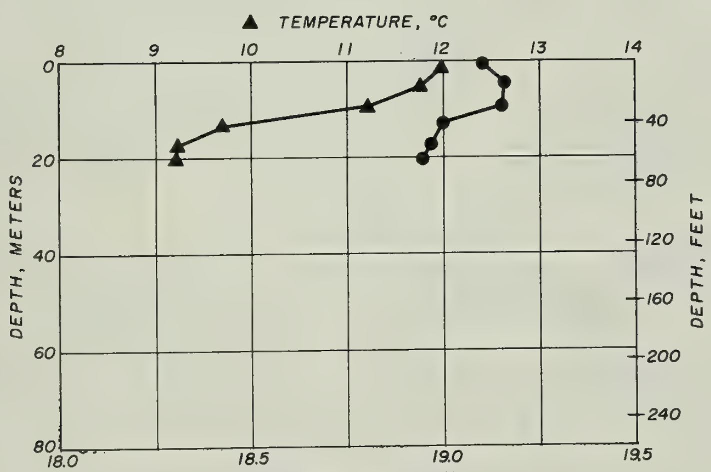
DATE 9/3/70 TIME 0355

DEPTH, M. 29 REF. FIG. 3



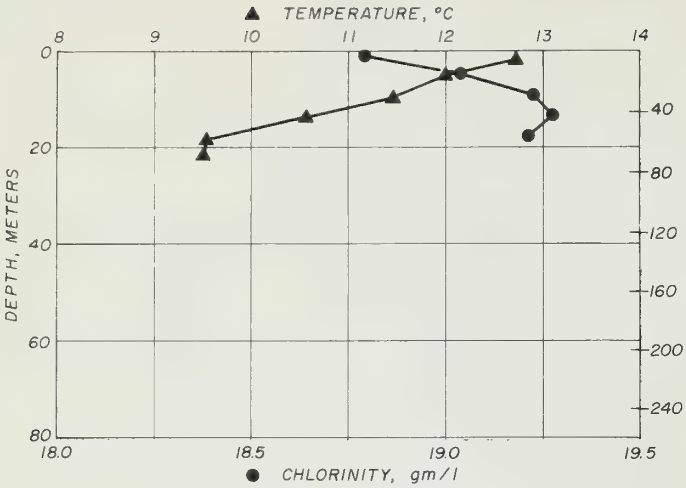
DATE 9/3/70 TIME 0430

DEPTH, M. 30 REF. FIG. 3



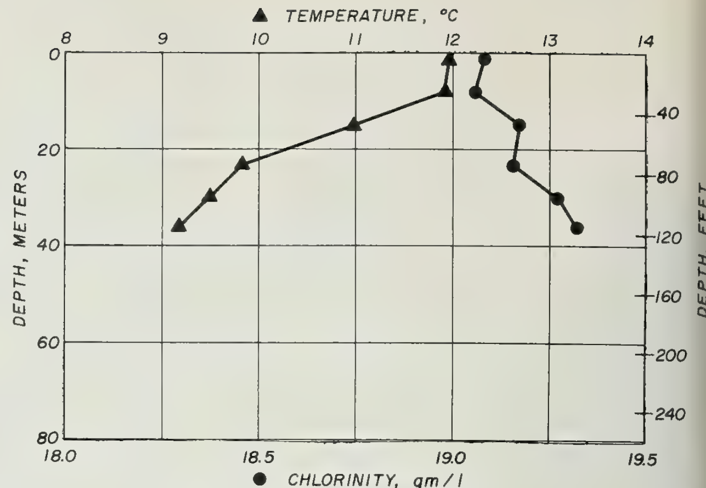
DATE 9/3/70 TIME 0504

DEPTH, M. 21 REF. FIG. 3



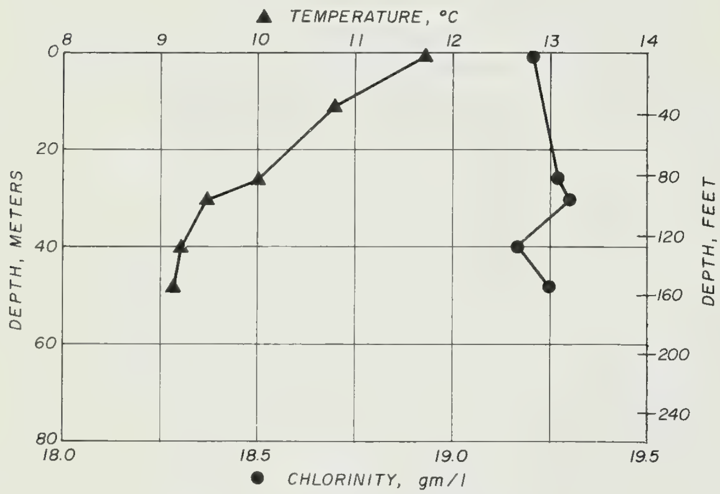
DATE 9/16/70 TIME 0130

DEPTH, M. 23 REF FIG. 3



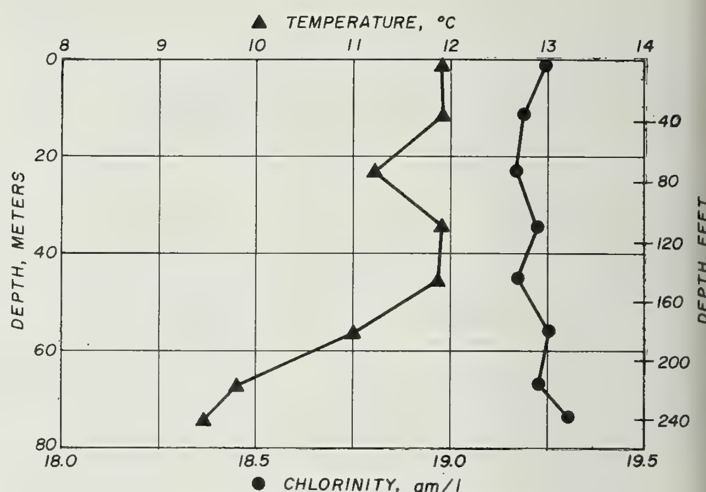
DATE 9/16/70 TIME 0225

DEPTH, M. 37 REF FIG. 3



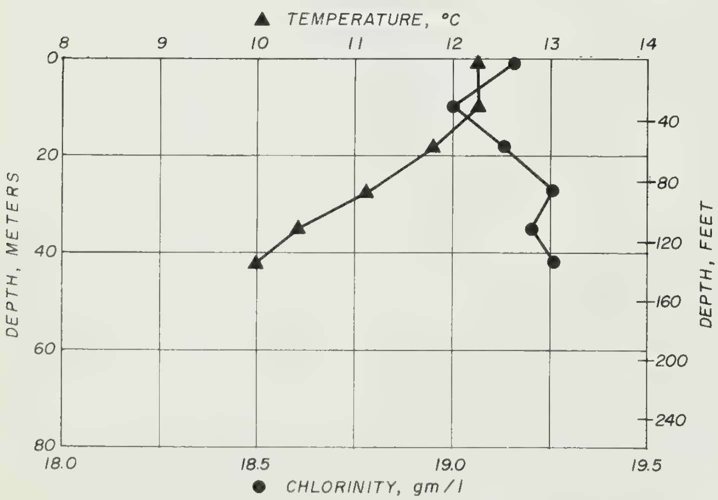
DATE 9/16/70 TIME 0312

DEPTH, M. 49 REF FIG. 3



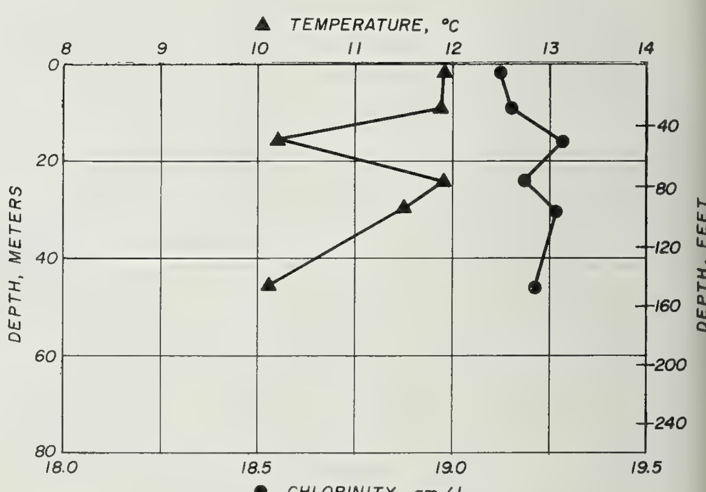
DATE 9/16/70 TIME 0357

DEPTH, M. 78 REF FIG. 3



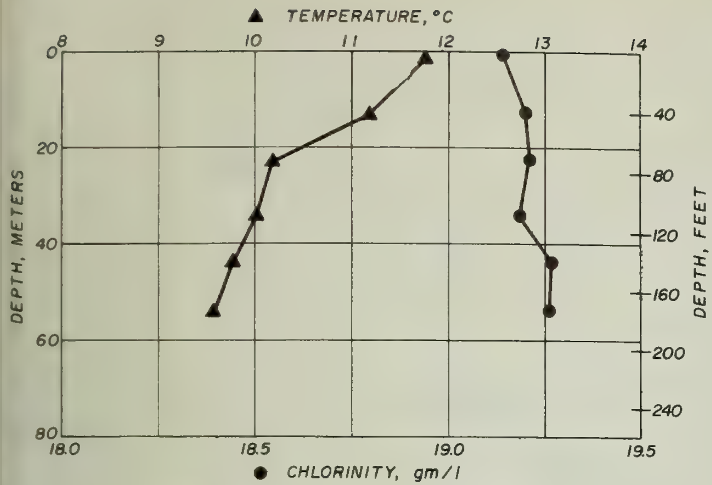
DATE 9/16/70 TIME 0450

DEPTH, M. 43 REF FIG. 3



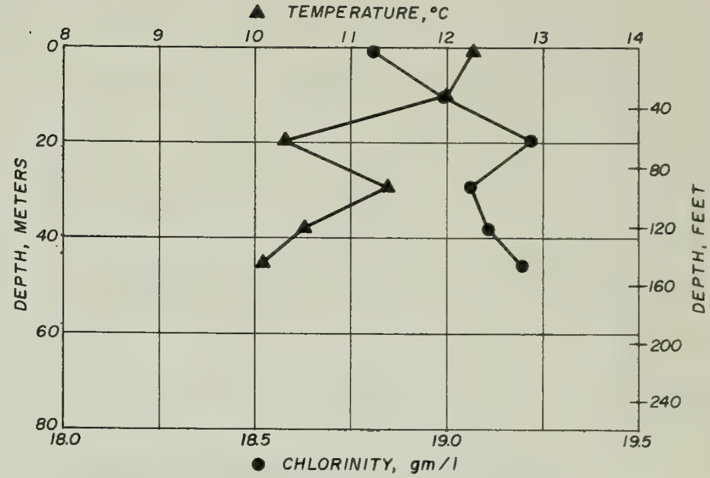
DATE 9/16/70 TIME 0527

DEPTH, M. 47 REF FIG. 3



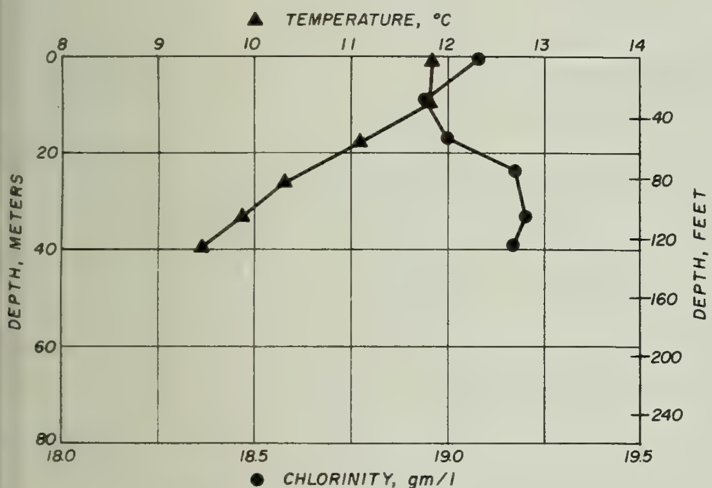
DATE 9/16/70 TIME 0622

DEPTH, M. 55 REF. FIG. 3



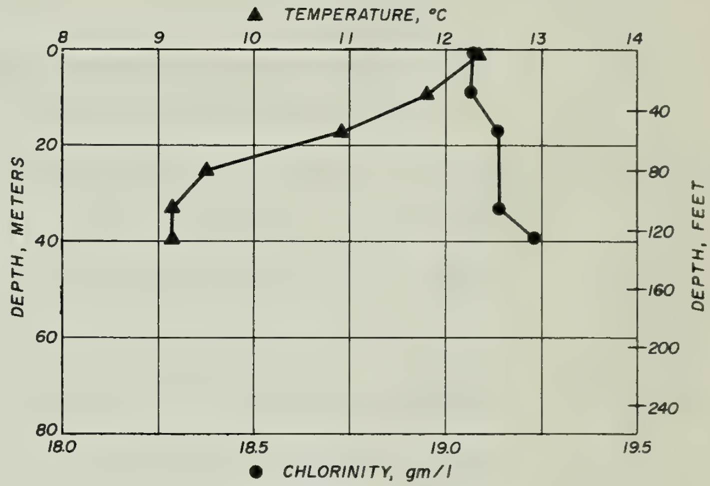
DATE 9/16/70 TIME 0717

DEPTH, M. 46 REF. FIG. 3



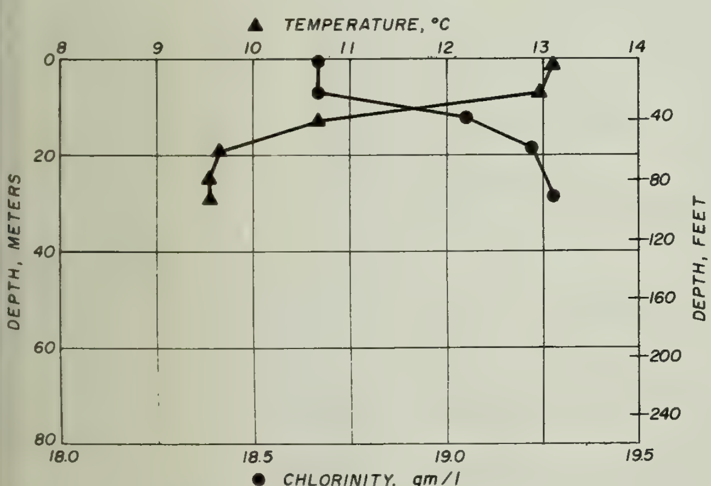
DATE 9/16/70 TIME 0808

DEPTH, M. 40 REF. FIG. 3



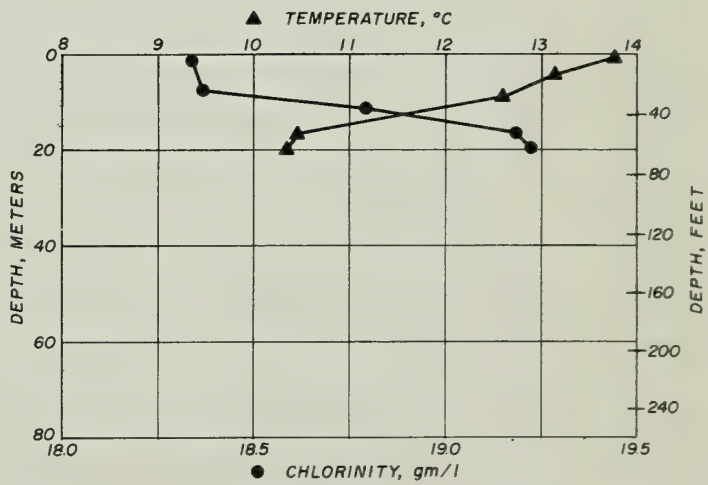
DATE 9/16/70 TIME 0855

DEPTH, M. 40 REF. FIG. 3



DATE 9/16/70 TIME 0937

DEPTH, M. 30 REF. FIG. 3



DATE 9/16/70 - TIME 0957

DEPTH, M. 21 REF. FIG. 3

Review of Biological Literature on Pacific Coast Marine Waste Disposal as a Guide to Prediction of Ecological Effects of a Submarine Outfall in the Gulf of the Farallones

Prepared for the City of San Francisco
by Wheeler J. North, December 1, 1970

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SECTION I

INTRODUCTION

To solve various waste disposal problems and meet certain requirements, the City of San Francisco is considering constructing an ocean outfall that will discharge south of the Golden Gate several thousand feet off Ocean Beach. This report attempts to assess the impact that can reasonably be expected on marine life in the dispersal area from such an outfall.

To establish a basis for such a prediction, pertinent literature describing observed effects from other Pacific coast outfalls was first reviewed and findings collated. The principal organisms known to be present in the receiving area were then identified and information on abundance fluctuations, as well as relevant biological details (*e.g.* life histories, feeding habits, sensitivities to discharged wastes, etc.), was considered. In the light of all assembled facts, the proposed outfall's expected consequences were then predicted.

SECTION II

REVIEW AND ANALYSIS OF BIOLOGICAL LITERATURE RELATING TO MARINE WASTE DISPOSAL ON THE PACIFIC COAST OF THE UNITED STATES

Generations of white men have used the Pacific Ocean off California, Oregon, and Washington for waste disposal purposes and undoubtedly the native indians dumped unwanted materials into the sea in earlier times. Literature on the subject is voluminous and we will consider only historical aspects and material dealing with ecological aspects of our sewage dispersal activities.

As cities emerged, the need for efficient sewage disposal systems grew. The most sophisticated systems appear to have developed earlier in southern California than elsewhere. Nineteenth century Los Angeles was centered several miles from the shore and was the first municipality to construct a major ocean outfall. This consisted of a 600-ft. long, cast iron pipe, 24 inches in diameter. Presumably most other cities that discharged to the sea were located closer to marine waters and did not require elaborate discharge facilities. As populations swelled, however, the need to avoid marine pollution problems was recognized and disposal systems have become ever more sophisticated.

History of the Southern California Outfalls

Discharges flowing into southern California coastal waters range from raw sewage trickling from individual houses to voluminous treated effluents from large metropolises. We will consider only the four largest discharges as there is

evidence that adverse ecologic effects from small (i.e., ca. 5 mgd outfalls) are negligible (Turner, et al., 1967). These discharges are the City of San Diego off Point Loma, County Sanitation Districts of Orange County off the Santa Ana River, Los Angeles County Sanitation Districts off Whites Point, and the City of Los Angeles off El Segundo (Figure 1). Changes in construction and operation at these sites has been summarized in Publication 26 of the State Water Quality Control Board (1964a).

Discharge volumes have trended upward over the years, although at times average flow may remain constant or even decrease slightly (Table 1). Total effluent entering southern California waters is now approaching a billion gallons per day.

The City of San Diego's discharge formerly was situated in inner San Diego Bay. In August 1963 a 108-inch diameter outfall, 11,430 feet long, discharging at depths of 200 to 220 feet was put into operation. Ultimate design flow is about 230 mgd (million gallons per day) but average daily volumes are presently about 80 mgd.

Orange County Sanitation Districts commenced operating in 1954, discharging at 60 foot depths through an outfall 78 inches in diameter and 7000 feet long. In 1965, 1000 feet of diffuser pipe was added, extending the discharge depth to about 100 feet. The Districts are currently constructing a 120-inch diameter outfall extending out 21,000 feet to a 195-foot depth, with a diffuser 6000 feet long. The new facility is expected to be operating early in 1971.

Four outfalls have been constructed by Los Angeles

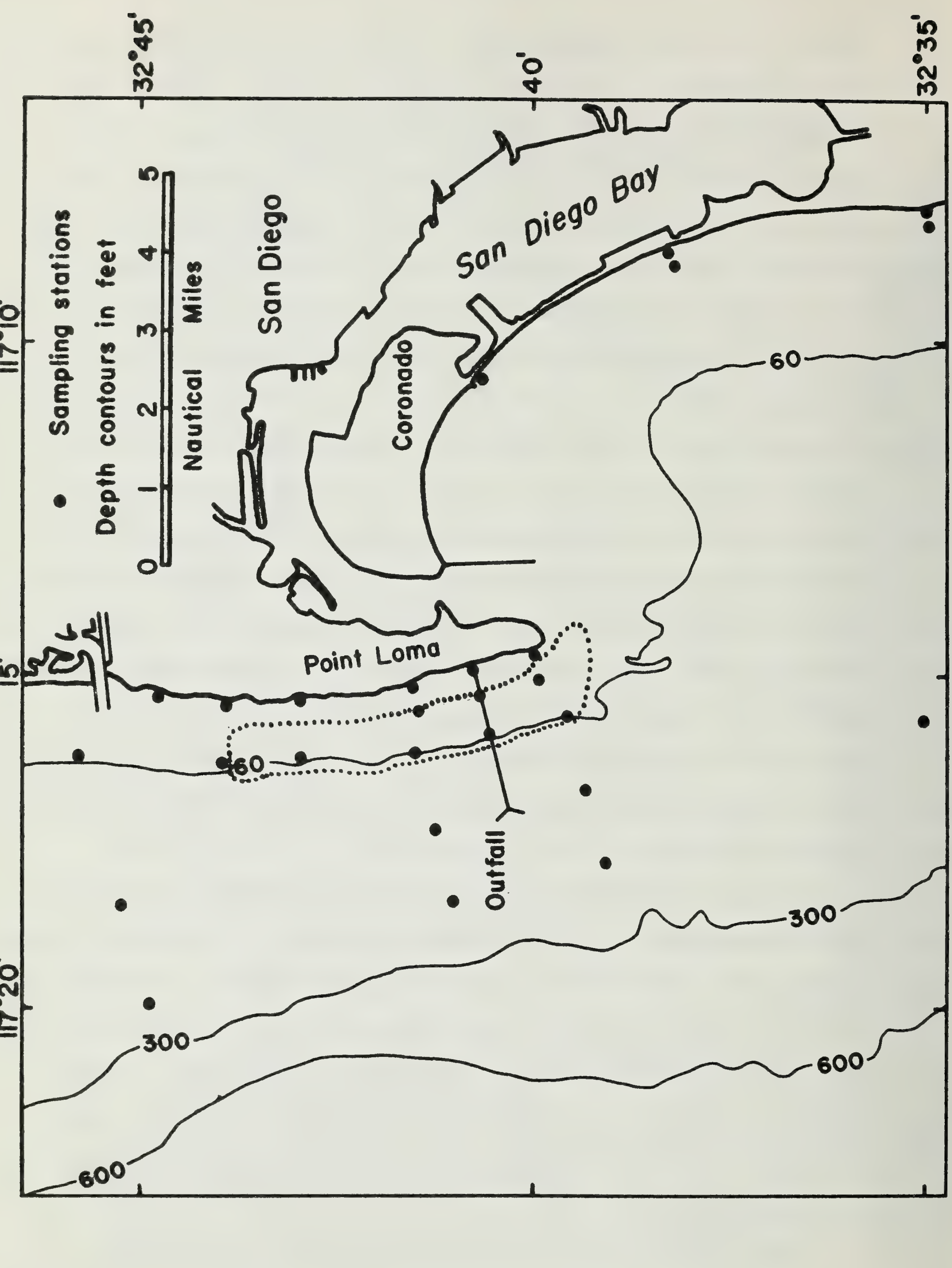

Figure 1a. Relation of San Diego outfall to sampling stations used in the City's monitoring program. Control stations are represented by the northernmost three and southernmost one dark circles. Dotted line shows kelp bed location.

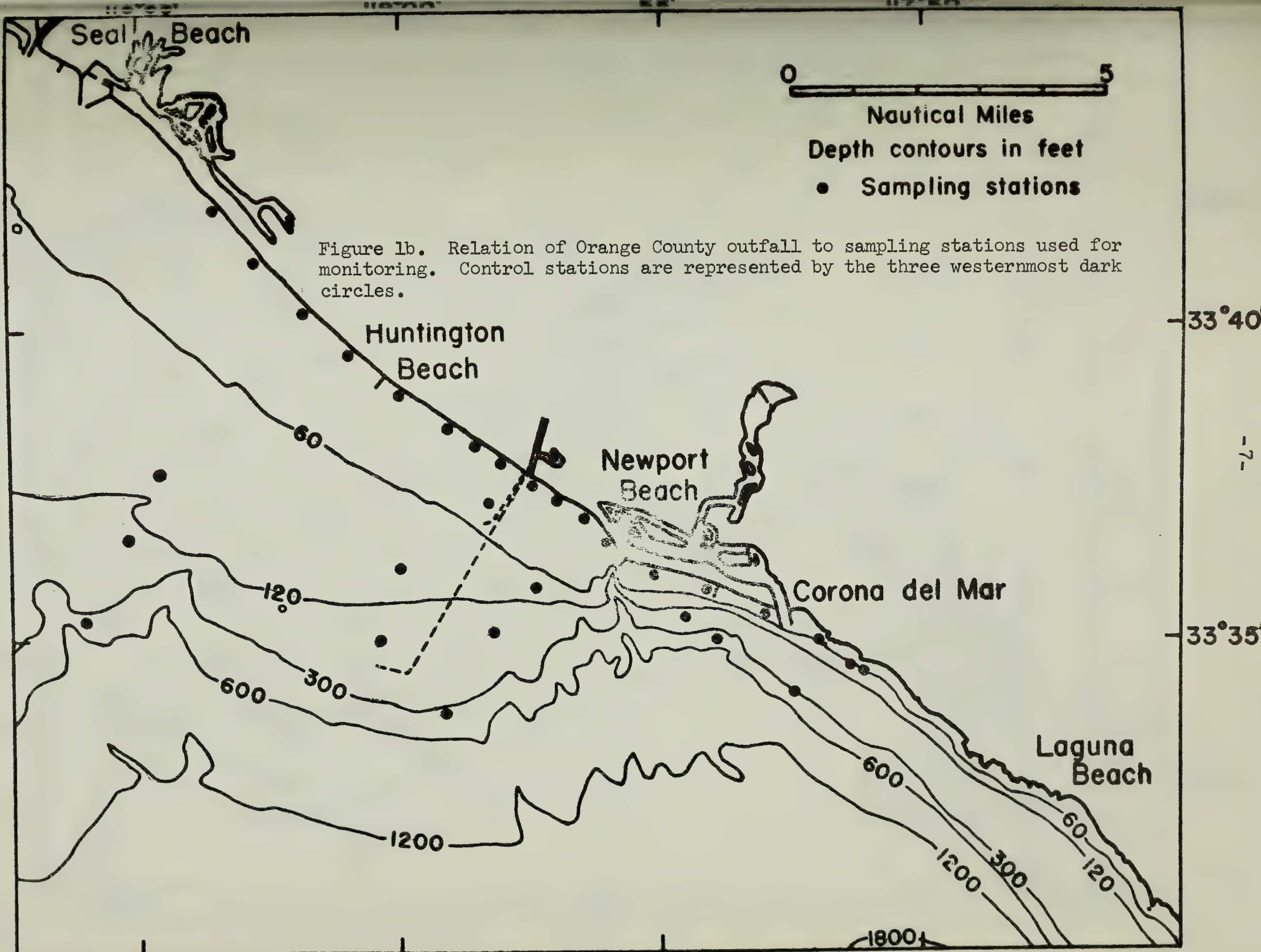

Figure 1b. Relation of Orange County outfall to sampling stations used for monitoring. Control stations are represented by the three westernmost dark circles.

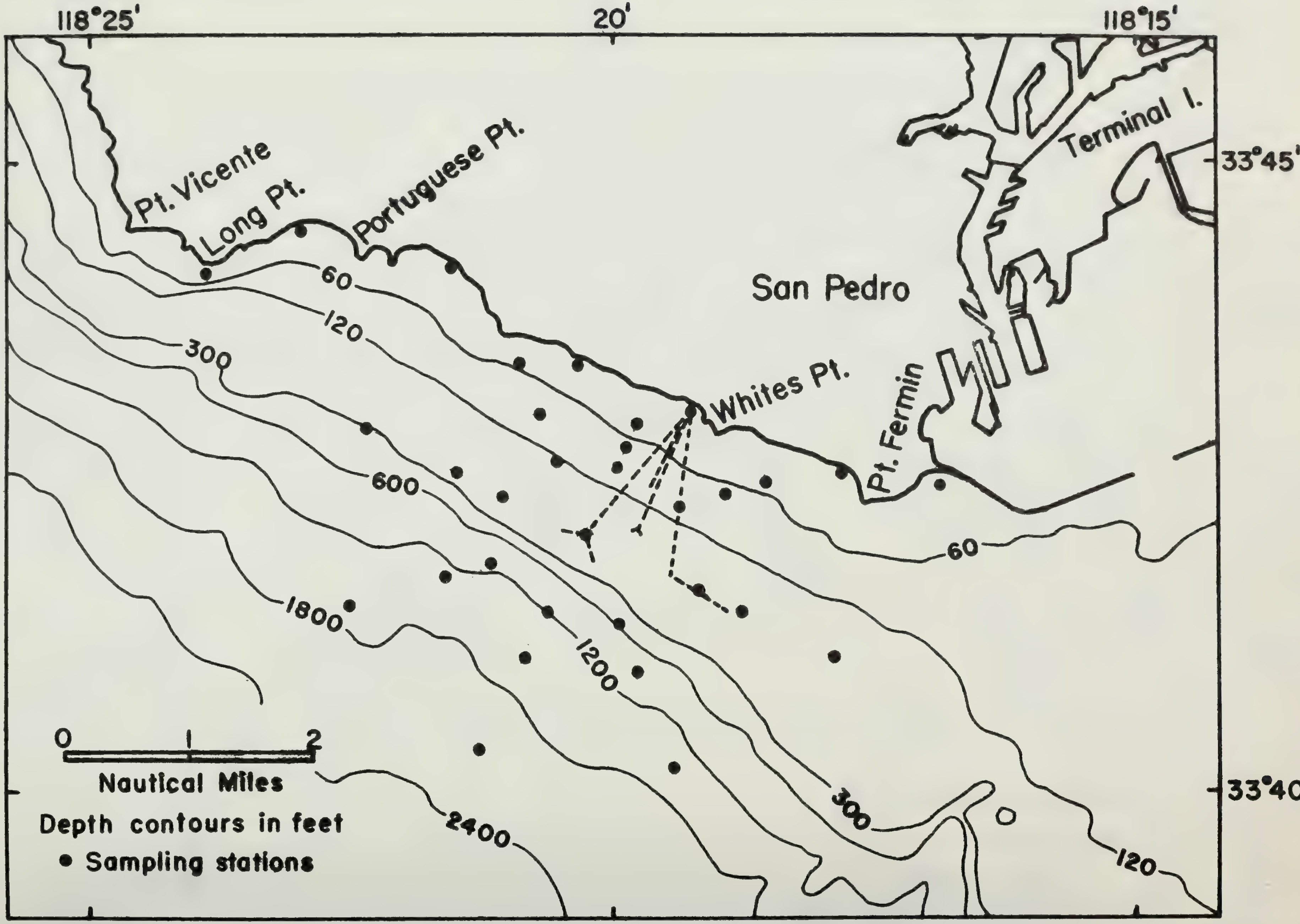

Figure 1c. Relation of Los Angeles County outfalls to radiating pattern of sampling stations used for monitoring. Four outfalls exist but only the longest two are in current use.

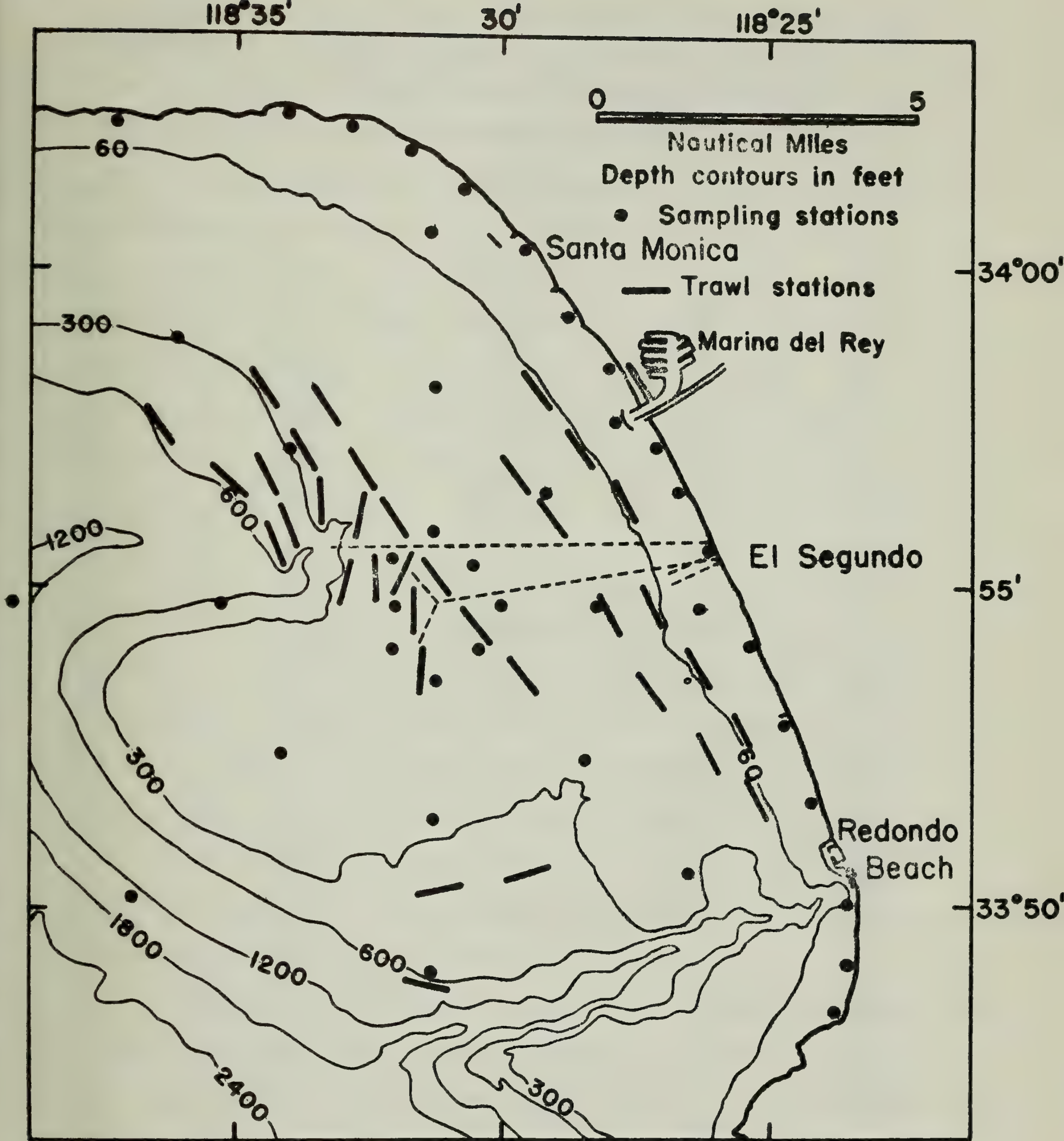

Figure 1d. Relation of Hyperion outfall (City of Los Angeles) to radiating pattern of monitoring stations (dark circles). Dark rectangles are trawling stations used in a special study by Carlisle (1969a,b).

TABLE 1

Effluent volumes in millions of gallons per day versus time for four major southern California discharges. Data supplied by City of San Diego, Orange County Sanitation Districts, Los Angeles County Sanitation Districts, and City of Los Angeles.

Year	San Diego	Orange County	L. A. County	L. A. City
1970	81	129*	384*	333
1969	84	125	373	344
1968	80	120	348	323
1967	73	114	336	317
1966	71	107	318	316
1965	63	95	302	293
1964	61	89	293	287
1963	48	82	288	283
1962	49	75	280	278
1961	48	66	274	261
1960	48	54	264	259
1959	45	52	248	262
1958	44	44	220	267
1957	43	37	195	256
1956	40	31	183	249
1955	39	24	180	244
1954	39		176	239
1953	38		154	230
1952	37		147	219
1951	32		125	193
1950	28		114	194
1949	25		104	199
1948	23		82	184
1947	21		59	178
1946	23		53	161
1945	22		52	160
1944	9.7		52	162
1943	5.2		47	148
1942			35	143
1941			34	144
1940			29	133
1939			25	130
1938			23	131
1937			20	131
1936			19	114
1935			18	113
1934			17	107
	1887			1894

*Portion of year only

County Sanitation Districts at Whites Point but only two are presently in use. These are a 90 inch diameter pipe completed in 1957, discharging about 200 feet deep, 7900 feet from shore through a wye diffuser. The other operational outfall was completed in 1966, is 120 inches in diameter, 11,830 feet long, with a single leg diffuser discharging at depths from 165 to 190 feet.

The Hyperion treatment plant operated at El Segundo by the City of Los Angeles discharges effluent through a 144 inch diameter pipe completed in 1961, 22,000 feet long, at depths of about 195 feet. Sludge is dispersed from a second pipe 36,960 feet long at a depth of 320 feet. Ultimate average design flow is 420 mgd.

Monitoring Programs

Marine life exists abundantly throughout southern California's waters and the principal safeguard against adverse ecological effects from discharged wastes has been monitoring programs imposed as requirements on dischargers by regional water quality control boards. Resolutions regulating the major outfalls always specify enjoyment and exploitation of marine life as beneficial uses. Resolutions invariably forbid adverse ecological effects due to effluents.

Chemical monitoring has included measurements of dissolved oxygen, pH, salinity, organic content of sediments, and levels of potentially toxic substances in effluents. Physical measurements include water transparency, light intensity at the bottom, and temperature. Biological evaluation programs have collected and analyzed composition and abundance changes of plankton and

benthos. In addition to required monitoring, agencies have undertaken various studies on their own initiative. These include observations on sludge deposits, NH_3, currents, trawling investigations, bioassays, and special uses of underwater television and photography.

The details of required monitoring vary from one installation to another (Table 2; also see State Water Quality Control Board, 1964b). Some differences arose because requirements for resource protection vary from region to region. Other dissimilarities have resulted because monitoring programs were designed at various times by different individuals. Probably the most modern and up-to-date program is the revised study effort of Orange County. Insufficient data has thus far been accumulated to assess this work.

Two special studies worthy of mention and representing non-required investigations were analysis of sedimentary infauna off Point Loma under contracts from the San Diego Regional Water Quality Control Board and extensive trawl studies conducted jointly by the City of Los Angeles and the Department of Fish and Game.

San Diego Analyses

Planning ahead for their Point Loma discharge, the City of San Diego authorized collection of background biologic and oceanographic data by San Diego Marine Consultants in 1958, five years before discharge operations commenced. The City assumed the data collection task in 1962 and has maintained staff and facilities ever since for both work at sea and laboratory

TABLE 2

Summary of monitoring requirements for various southern California dischargers.

Measurement		LACSD	CLA	OCSD new	CSD
Coliform	Offshore	BW	100/ml	BW	BW
	Beach		BW	70/100ml	
Dissolved oxygen (min ppm)		6	6	6	
Grease (min ppm)		2	2		
Transparency		Secchi	Secchi	suitable for kelp*	Hydrophotometer <10% vs control
OM sediments		<3%/yr	<3%/yr		<10%/yr
Sludge			no sig.		
Toxicities		none	none	none	bioassay
Effluent anal.		hrly	hrly	24 hr avg	24 hr avg
pH				7-8.6	
Temperature					X
Salinity					X
Floatables, slicks, oil, etc		none	X	none	2%
Odors		none	none	none	none
Turbidity or color change			none	none	
Beach deposits		none	none	none	none
Plankton					discont'd. 1967
Benthos				X	X

(continued)

TABLE 2 (cont'd)

Remarks

BW = Bathing water standards

LACSD : (special, not required) currents, water temperature

CLA : not required (weekly) salinity, plankton, NH_3, recreational usage; (quarterly) benthic trawls; (special) sludge, currents, hydrophotometer, underwater photo and TV, internal waves, bioassay

OCSD : (special) currents; (routine) trawling, diving, grab samples;*bottom light requirements given by Anderson and North (1969)

CSD : (special) bioassay; (routine) grab samples

analysis. Periodically the San Diego Regional Water Quality Control Board has used consultants to analyze trends in the enormous quantities of accumulated data.

An important administrative problem has been continually encountered. Turnover of personnel conducting the surveys has been frequent (J. E. McKee, personal communication). The impact is more serious in the work involving specimen identification, rather than in the collection efforts which are fairly well standardized. Many of the species are difficult to identify and many months are usually required to train a new technician to the desired level of competence (it has not been feasible to employ specialists for identification work because such individuals invariably are unwilling to leave academic positions). The identification tasks are extremely tedious and individuals have quickly tired of the work and sought employment elsewhere. Reliability of identifications has varied from individual to individual as well as during the length of time a particular technician has remained on the job. It should be noted that for good quality ecological work, precise identification to the species level is a *sine qua non*.

For the first six years a series of sedimentary grab samples were collected twice yearly. During 1968-69, sampling was reduced to once per annum. Quadruplicate samples were taken at each of seven stations around the dispersal zone surrounding the outfall (Stations A-1 to A-7, Figure 1A) as well as from four reference stations (Stations B-1 to B-4, Figure 1A) five miles up and down the coast from the outfall. Chemical and Biological processing was accomplished by City staff. Trend

analyses by Regional Board consultants computed means, standard deviations, etc., for all parameters. Significances of differences were assessed by t-testing (physical and chemical parameters) and variance ratio tests (biological parameters). Seasonal variations and long-term trends were discerned by regression analyses and the various taxonomical groupings were ranked by uses of means, frequencies, and prominence values. Changes in community structure were examined by a similarity index.

The earliest analysis covered the period May 1962 to March 1965 (Marine Advisers, 1965). Of 211 taxonomic groups examined, means of 57 changed significantly ($p=0.01$) following initiation of discharge operations at Point Loma in August 1963. Of the 57 changes, only 8 represented decreases and only two of the eight might have been caused by waste disposal. Population increases were observed in 39 groups. Overall it was concluded that the benthos benefitted from outfall operation.

Two years later, Water Resources Engineers (1967) repeated the Marine Advisers analysis, extending it to include data collected through December 1966. Benthic populations had tripled in numbers, both at the dispersion area and the reference stations. Biomasses remained relatively unchanged, however, so it appeared that population abundance increases represented appearance of small juveniles. Agreeing with the Marine Advisers study, Water Resources Engineers concluded that the overall effect of the outfall had been beneficial. It is noteworthy that the City had been forced to discharge well-digested sludge through the outfall from September 1964 to January 1967 because

of repair work required for a line conducting sludge to a land-disposal site during normal operation.

Evidence that the discharge was not creating adverse ecological effects was considered sufficiently strong to allow reduction in monitoring effort. Phytoplankton analyses were discontinued and the sediment survey was changed to a biennial basis. In August, 1968, a five month emergency discharge of raw settled sludge was allowed through the outfall to permit removal of grit accumulation in the digesters (the volume of sludge discharged at any one time was about one third of plant capacity). Because the next scheduled sediment collection would not occur till summer 1970, a special collection was made in January 1969 after all digesters were back in full service.

All data collected through December 1969 were analyzed by Water Resources Engineers (1970; also see Chen, 1970). Total number of taxonomic groups was reduced to 137 by incorporating lesser taxa into higher categories. As a result, the lowest taxon used was family for Polychetes, Mollusks and Echinoderms. Crustaceans were recognized to orders, and classes or higher taxa were employed for other phyla. Even the resulting reduction from 211 to 137 groupings was apparently still somewhat unwieldy because the report states "While manageable with the aid of the computer, this list is still regarded as a bit too long for most convenient use."

The principal trend among benthic populations was "a general rise in the total numbers of organisms; a rapid increase in the period immediately following discharge followed by some readjustment in numbers, biomass, and bioindex as the benthic communities

acclimatized to the imposed nutrient load. In the majority of cases, overstimulation of the benthos occurred, that is, organisms tended to grow in numbers beyond their food supply in the first few years, populations subsequently dropped and, as might be expected, individuals in the community tended to be smaller in size." In most cases the moderate recessions in later years still left population levels well above densities found before discharge operations commenced. Some groups had experience no recession, merely a reduction in the rate of increase.

A discussion of the fate of the ten groups ranked highest at the time discharge operations began, showed that six remained as dominants five years later, one had fallen below the top ten, one had risen into the top ten, and the fate of three groups (Sipunculoidea, Ostracoda, and Nuculanidae) is not explained as they do not appear in the graph after the discharge commenced. The text concluded that there were no dramatic changes in community composition. There was also no defined change in diversity at most stations. Some changes were noted at a control station, B-2. This shallow station also displayed increased quantities of sand in the sediment samples, suggesting that sand shifts (which occur normally on shoal bottoms) may have influenced resident populations.

Other chemical and physical parameters were discussed in the Marine Advisers and Water Resources Engineers reports. Water transparency, dissolved oxygen, temperature, and sediment nitrogen showed little relation to the discharge. Organic content of sediments (as measured by BOD) increased substantially

following outfall operation, particularly in the immediate vicinity of the wye diffuser. The increase extended to control stations (as did increases in benthic populations). The Water Resources Engineers reports concluded that the rather subtle effects were, therefore, widespread and the outfall was disseminating the load efficiently and functioning as intended.

One factor appears to have been overlooked by all analyses, the restoration of a kelp bed at Point Loma from 1963 to 1969 (this event will be described in greater detail below). Organic production by the bed was probably equal to or greater than organic input from the outfall from 1963 to 1969 (Table 3). Our calculations represent productivity by only one species (giant kelp admittedly dominant and probably the most important producer). If other plant species were included, natural productivity would probably be 1.5 to 2 times higher. Moreover, the seaweed-created organics probably are more readily consumed and digested by native herbivores than sewage because deteriorating seaweeds are natural foods within the area. Phytoplankton productivity would be about a sixth of the larger kelp values (Clendenning, 1960). As the kelp is distributed along most of the length of Point Loma (Figure 1A), changes at the control stations B-2, B-3, and B-4 might well be caused by this natural source of organics rather than the outfall. It is interesting that this intermediate size outfall (roughly equivalent in size to the proposed discharge by the City of San Francisco into the Gulf of the Farallones) discharges approximately as much organic matter as is generated by local plant productivity.

TABLE 3

Computed productivity of the Point Loma stand of giant kelp (Macrocystis pyrifera) and organic output from the San Diego outfall vs. time. Plant productivity was calculated from Clendenning's (1960) estimates of organic matter yielded annually by a kelp bed. Because the Point Loma bed is extraordinarily productive (as judged by yearly harvest yields) a value of 13.3 tons of organic matter per acre-year was used as the productivity (this is close to the upper limit of normality given by Clendenning). Outfall organic output was calculated using the average BOD content of 200 mg/l for San Diego effluent (Water Resources Engineers, 1970).

Year	1960	1961	1962	1963	1964	1965	1966	1967	1968	1969
Area of kelp bed, mi^2	0.03	0.01	-	0.1	1.2	1.6	2.0	3.5	3.0	3.2
Kelp productivity, tons organics/day	0.7	0.2		2.3	28	37	47	82	70	74
Discharge volume, mgd					56	63	71	73	80	84
Outfall output, tons organics/day					47	53	59	61	67	70

Santa Monica Bay Trawl Studies

The Department of Fish and Game and the Bureau of Sanitation, City of Los Angeles, jointly conducted a trawling survey in Santa Monica Bay from 1958 to 1963. Quarterly bottom tows at 39 stations totalled 705 hauls at depths from 60 to 600 feet. The study yielded 112,799 fishes of 104 species (Carlisle, 1969a) Numbers of invertebrates were not reported by species identifications included 2 coelenterates, 1 echiuroid, 4 annelids, 23 crustaceans, 119 mollusks, 3 brachiopods, and 11 echinoderms (Carlisle, 1969b). Many other species were recovered but not

identified. The vessel used was a 65-foot converted salmon troller. The net had a 25 foot cable bridle and 12 by 18 inch otter boards in the wings. Net length was 24 feet, body mesh was 1½ inch, and liner mesh was ½ inch.

Problems arising from identifying difficult species were resolved by concentrating on fishes, a group that the Department's State Fisheries Laboratory is well-qualified to handle. The task was further simplified by the fact that the majority of fish species were only occasional recoveries. Catches were dominated by a relatively small number of species. For example, only 35 fish species out of the 104 total recovered displayed frequencies greater than 0.14 (i.e. were captured in 100 or more hauls out of 704). The six year catch of the five most abundant fishes amounted to 83,713 individuals or 74 percent of all specimens taken.

Carlisle's (1969 a,b) analyses failed to show any adverse influence by the Hyperion Outfall both from material he recovered and from an examination of partyboat catch statistics for Santa Monica Bay from 1958 to 1963. Carlisle did note that certain fish species appear to be attracted to sludge-enriched areas while others avoided them. The study was designed to sample Santa Monica Bay for three years before and after discharge operations commenced in 1961 from the five mile long outfall of the Hyperion treatment plant. Prior to 1961, a slightly lower volume had been discharged closer to shore from an outfall one mile long, 12 feet in diameter, terminating at a depth of 69 feet (Table 1, Figure 1C). Consequently the "background" portion of Carlisle's study did not represent a period

when the region was entirely free from exposure to effluent. Possibly operation of the new outfall in 1961 caused changes in distribution of sensitive species but the overall yields from Santa Monica Bay (as indicated by partyboat statistics) remained essentially constant.

The San Diego and Santa Monica Bay studies both encountered a difficulty that affects most monitoring programs, namely the problem of accurate taxonomic identifications. Any careful collection effort invariably recovers several hundred species, many of which can only be processed by specialists if correct identifications are to be obtained. Without accurate identifications to species level, data loses much of its ecological value. The monitoring program recently undertaken by the Orange County Sanitation Districts attempts to resolve the taxonomic problem by identifying and enumerating only dominant species although all collected organisms are preserved and stored in case future events indicate a more detailed analysis is necessary.

Other Biological Studies

Much information has been gathered by independent investigators and consultants on conditions near submarine outfalls in our Pacific coastal waters. We will first discuss studies that relate to general phenomena and conditions. Then we will summarize publications describing specific regions.

General Studies

Ludwig and Ondera (1964) and State Water Quality Control Board (1964b) described kinds of data being collected by various

monitoring programs and State-sponsored studies in California. Discussions emphasized technique but a few results as well as representative values of parameters were presented. A "state-of-the-art" description by Gunnerson (1961) reflected the paucity of work accomplished on the Pacific coast up to that time and many conclusions were derived from studies conducted elsewhere. Gunnerson's bibliography identifies most of the relevent early literature.

In the mid-1950's, the State Water Pollution Control Board decided to support a careful biological survey of the continental shelf, primarily to establish background conditions as a basis for evaluating future changes. The study was conducted by the University of Southern California's Allan Hancock Foundation from 1956 to 1960. Information on water temperature, salinity, dissolved oxygen, phosphate, silicate, nitrate, pH, transparency, light transmission, sediment characteristics, microplankton, sedimentary fauna, foraminifera, and intertidal algae was gathered. Stations occupied totaled 732. The extensive data have been tabulated (State Water Control Board, 1965a) but several categories were incompletely analyzed. Some of the stations were near sewer outfalls and effects on plant and animal distributions were briefly described. We will refer to such remarks below when we discuss the various outfalls individually. The survey identified 17 types of bottom communities according to dominant species present (i.e. *Amphiodia*-*Cardita* community). Subtidal sampling employed an orange-peel grab so little data was available from rocky bottoms. The project was able to survey rocky substrate occurring intertidally and 44 transects

from Point Conception to La Jolla were analyzed, emphasizing algal distributions.

Much additional background information relating to subtidal conditions is available from studies of artificial reefs conducted by Department of Fish and Game diving biologists (Carlisle _et_ _al_., 1964; Turner _et_ _al_., 1969). Although most of the substrates observed were man-made, (oil platforms, quarry rock, concrete blocks, auto and streetcar bodies, etc.) the extensive species lists and long-term succession studies contained in the reports are extremely useful for characterizing rocky bottom communities of the regions. Background material was collected by North (1963, 1964a, 1965) for kelp beds at Canyon de las Encinas, San Elijo Lagoon, and Point Loma.

Gunnerson (1961) stated that "evidence for greater production of marine plankton in the vicinity of sewage-effluent discharges is strong", citing studies from Florida, Oslo Fjord, and the Mediterranean as support. This conclusion has since been verified for southern California waters by Tibby _et_ _al_. (1964; see also State Water Quality Control Board, 1965b). These workers found an initial depression of phytoplankton productivity as sewage and seawater became mixed near the Orange County outfall. After about eight hours a substantial increase in carbon-14 uptake was noted, lasting about two hours. No correlations were found between productivity and concentrations of phosphate, silicate, and ammonia. Stevenson and Grady (1956) usually found increases in planktonic concentrations near outfall "boils". Occasionally the effect could be traced to a

12,000 foot distance. These authors did not believe that effluent mixtures caused plankton "blooms" (marked concentration increases) but they surmised that discharged nutrients might enhance bloom intensities. Gunnerson (1961) could find no convincing evidence that the subtle fertilization effects of sewage could lead to dense plankton blooms or eutrophication in open coastal waters although such effects may occur in semi-enclosed situations. Tibby et al. concurred (State Water Quality Control Board, 1965b). Comparing microplankton counts from 59 stations near outfalls, with counts from all 800 stations surveyed, the Allan Hancock Foundation was unable to find any differences among numbers of dinoflagellates recovered, but reported a significantly greater mean value for diatoms from the outfall stations (differences in means were 2.9 times the standard error, State Water Quality Control Board, 1965a). Influences on individual species were not determined. North (1969) reviewed the Allan Hancock Foundation microplankton data for their subregion 5 (Bolsa Bay to Laguna Beach in Orange County) which contained the Orange County outfall. During the time of the Foundation's study, the Orange County outfall was the only discharge in southern California consistently reaching the surface. Sixty three stations in the vicinity of the outfall were analyzed by North (Figure 2), representing 156 samples. The principal groups were diatoms (39 species or higher taxa), dinoflagellates (8 species or higher taxa), and protozoans (11 species). Only the diatom Skeletonema costatum occurred exclusively in the vicinity of the outfall and might be associated

with the wastes. North cautioned, however, that more data would be needed to establish that *Skeletonema* was indeed responding to sewage effluent and not the peculiar oceanographic conditions that characterize submarine canyons (the outfall runs along the western edge of the Newport submarine canyon, Figure 2). Clendenning and Sweezey (1958) believed that there may have been an association between sewage effluent and cryptomonads in San Diego Bay. The City of San Diego conducted surface to 20 foot depth plankton tows for five years near their Point Loma outfall (a discharge that rarely, if ever, extends to within 20 feet of the surface). A total of 80 groups that included 35 species were segregated during processing. Several species may have responded to the Point Loma discharge (*Ceratium dens*, *Ceratium furca*, and *Noctiluca* sp. may have increased temporarily, *Skeletonema costatum* and *Oxytoxum* sp. may have increased, particularly during a period of sludge discharge). Overall, however, it was concluded that influences on planktonic communities were negligible (Marine Advisers, 1965; Water Resources Engineers, 1967). This study was certainly the most detailed effort and the most carefully analyzed work of its kind ever conducted on the Pacific coast. As a result, the Regional Water Quality Control Board was convinced that the San Diego discharge was not influencing planktonic communities significantly and the City was allow to discontinue this exceedingly costly program.

The problems associated with conducting meaningful plankton studies have plagued almost every survey that has examined this type of community near outfalls. Species identification

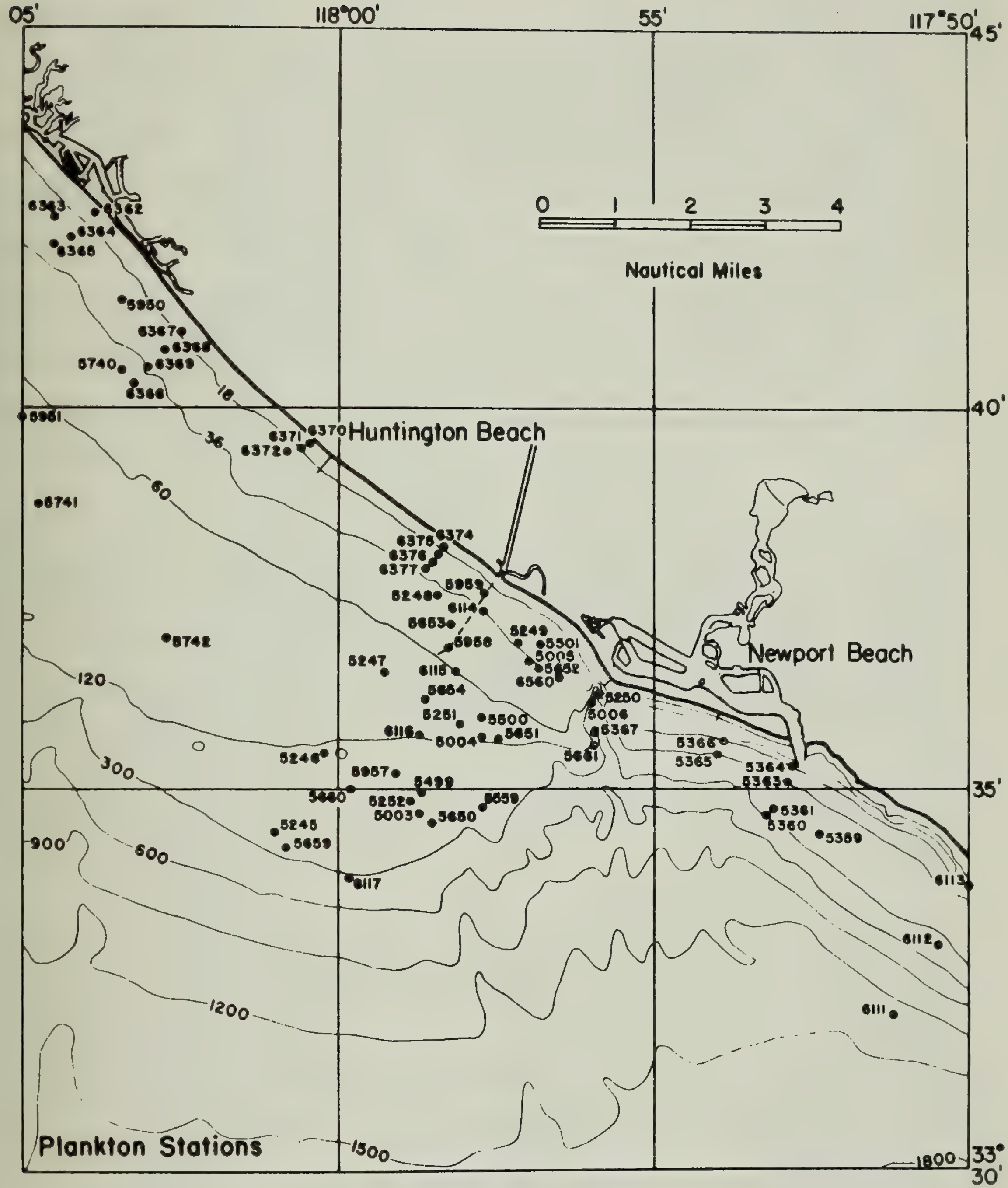

Figure 2. Plankton stations occupied during the Allan Hancock Foundation study (State Water Quality Control Board, 1965a).

requires highly specialized and painstaking efforts from collection to identification (Lackey, 1960). Personnel with necessary skills are often unavailable. The City of San Diego studies were hampered by high turnover rates among technical personnel. Abundance variations even for a single species can be enormous, sometimes spanning five or six orders of magnitude during a single collection series. Vertical migrations, tendencies to form stratified distributions under certain (usually unknown) conditions, horizontal transport by currents, and other factors introduce transients leading to profound abundance fluctuations within hours or even minutes (Table 4).

TABLE 4

Abundances of principal diatom and dinoflagellate genera recovered from three water samples gathered at a single station within a ten minute period on 21 June 1958. Sample size was about 1 liter. Numbers represent estimated organisms per liter. Data from San Diego Marine Consultants (1959b). Note how concentrations of some genera remained fairly stable (*e.g.* *Ceratium*) while others fluctuated greatly (*e.g.* *Coscinodiscus*).

Genus	Sample depth, feet		
	0	1	1
Ceratium	51,000	38,000	33,000
Gonyaulax	16,000	60,000	26,000
Peridinium	7,500	13,000	4,300
Prorocentrum	20,000	7,300	7,600
Chaetoceros	370	0	0
Coscinodiscus	12,000	130,000	0
Rhizosolenia	400	170	500

Planktonic distributions range from fairly uniform to highly

patchy (Figure 3). The inflexible station patterns established for typical surveys are usually unable to take account of the enormous spatial and temporal variability that often occurs among planktonic populations.

Effects of discharged wastes on kelp beds have been exhaustively studied. Giant kelp (Macrocystis spp.) forms an underwater forest type of habitat that attracts, shelters, and nourishes a variety of marine life. The plants are also harvested and processed for chemicals as well as added to fertilizers and animal feeds. Kelp beds near San Diego and Point Loma began receeding in the mid-'40's and had almost totally disappeared by 1960. Recession patterns implicated sewage discharge areas (State Water Quality Control Board, 1964a). Properly diluted composite samples of wastes, however, stimulated photosynthesis in kelp (Clendenning, 1958). Kelp bed disappearance was found to be directly caused by severe grazing pressure resulting from persistent swarms of sea urchins near certain outfalls (North, 1964b). In one case at Santa Barbara, kelp growth was relatively unaffected by a nearby outfall. The substrate at Santa Barbara was found to be unsuited for urchins and very few of these animals occurred there. Kelp growth rate was high, probably encouraged by nutrients from the outfall. Destructive grazing by urchins was also observed in areas remote from outfalls, but in such instances urchin populations eventually disappeared (presumably from starvation) and kelp returned. Near outfalls, urchin populations did not disappear following kelp destruction and the high concentrations prevented development of any

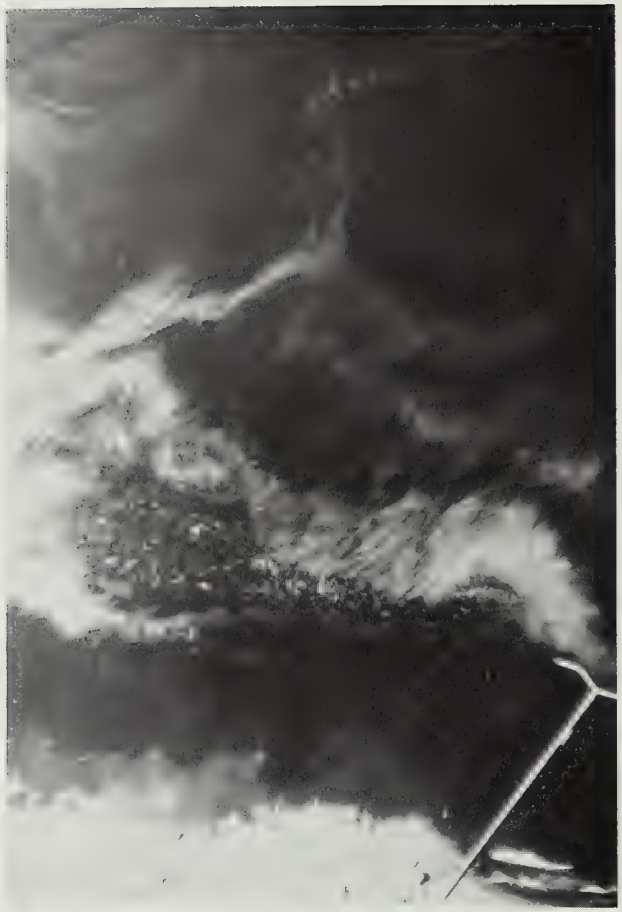

Figure 3. Infrared aerial photograph (10,000 feet altitude) showing complex surface distribution of a plankton bloom off Ocean Beach California on October 28, 1970. Wispy white cloudlike areas are plankton and extend downward diagonally from the pierend. Kelp plants (scattered white specks) border inshore edoe of the plankton bloom. Grid patterns used in conventional plankton sampling would probably characterize this distribution very poorly.

vegetation. Pearse et al. (1970) presented evidence that urchins could receive nourishment from discharged wastes. Physiological examinations of animals collected from outfall areas showed them to be adequately nourished although they had no access to natural food supplies. Leighton et al. (1967) demonstrated that kelp beds could be restored by artificially controlling urchins. An urchin control program is now conducted by the Kelco Company (a San Diego-based kelp harvesting concern). This program, conducted in conjunction with the California Institute of Technology, has succeeded in restoring most of the Point Loma kelp bed (Figure 4).

Specific Investigations

San Diego Bay

San Diego Bay received effluent from the City until the new outfall off Point Loma was put into operation in 1963. Large sludge beds had accumulated from the years of waste disposal (San Diego Regional Water Pollution Control Board, 1952). The author inspected the region near the discharge many times by scuba diving in the late 1950s and observed very little life. Cessation of waste disposal caused slow improvement and recent reports indicate that biota is abundant and the bay appears to be in healthy condition (Federal Water Pollution Control Administration, 1969; North, 1970). Interestingly, during years when the bay received sewage effluent, the waters supported a flourishing live bait fishery (principally anchovy). After waste disposal was discontinued, the live bait fishery operated primarily in the adjacent open sea(C. Martin,personal communication)

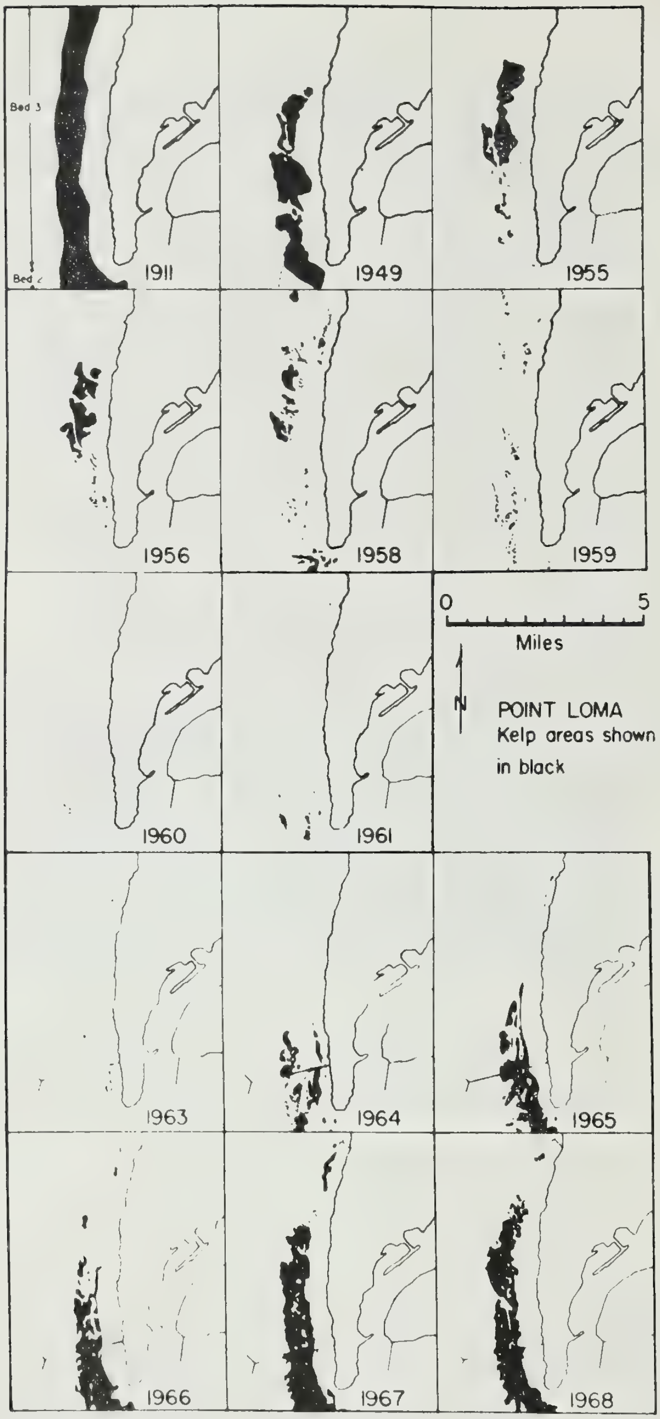

Figure 4. Historical charts of the Point Loma kelp bed (shown as black); 1963 to 1966 from oblique photos, courtesy Kelco Company. Years 1963 to 1968 represent fall conditions.

Point Loma

The monitoring studies conducted by the City of San Diego at their outfall site off Point Loma were described above. Additional work was conducted in 1965 by diving biologists from the Department of Fish and Game. Comparisons were made with data collected by San Diego Marine Consultants (1961). Much additional survey and collection work was undertaken. The study indicated a diverse and abundant fauna and flora existed on the rocky shelf inshore from the outfall and no adverse effects attributable to the outfall were observed (Turner *et al*., 1968). Grab samples of sediment close to the terminus did not yield sludge but species composition of the infauna suggested influence by the discharge.

Canyon de las Encinas

Department of Fish and Game divers conducted background (1962) and post-discharge (1967) surveys near the small (2.2 mgd) sewer outfall off Canyon de las Encinas to note any changes caused by the operation. Principal changes involved increased abundances of sand anemonies, hermit crabs, sand stars, and white urchins (Turner *et al*., 1967). Diversities and abundances of species colonizing the outfall structure were considered normal for the age of the "reef". Overall, no adverse influences of outfall operation were noted.

Pre- and post-discharge studies were conducted on kelp beds near Canyon de las Encinas (North, 1963; North, 1968). Parameters measured were kelp abundance, plant size, growth rate, mortality, and reproduction as evidenced by abundance of

juveniles. No adverse effects were found. The beds have remained luxuriant (as indicated by surface canopies) up to the present.

Orange County Outfall

Diving biologists from the Department of Fish and Game surveyed biota near the Orange County Sanitation Districts discharge off the Santa Ana River in early 1965. A nearby artificial reef was also inspected. Numbers and kinds of sedimentary fauna appeared normal as did communities encrusting most of the outfall structure (Turner et al., 1966). The last 100 feet of outfall pipe displayed reduced species diversity and there were indications of impoverishment on the artificial reef. The general biological impact of the discharge was nonetheless considered small.

Harbor Complex

An extensive series of coastal modifications extends from Point Fermin to Bolsa Bay, including Los Angeles Harbor, Long Beach Harbor, Alamitos Bay, the modified entrance to San Gabriel River, and a soil disposal area off Sunset Beach. The region receives numerous domestic and industrial discharges. A variety of studies have documented conditions in the harbor complex. In general, inner Los Angeles Harbor has been the most biologically impoverished area (Reish, 1960) but conditions improve in a southeasterly direction so that outer Los Angeles Harbor and Long Beach Harbor appear fairly normal (Reish, 1961a). Alamitos Bay was considered roughly equivalent to unpolluted Newport Bay (Reish, 1961b) and the only indication of abnormality found by Turner and Strachan (1969) at the San Gabriel

River mouth was a lack of fleshy brown algae. Adverse effects of discharged wastes in the harbor complex are thus probably related to available volume for dilution and intensity of mixing processes. Clearly these factors are not adequate to avoid adverse ecological deterioration in the inner reaches of Los Angeles Harbor.

Palos Verdes

The gradual decline of kelp beds off Palos Verdes has been documented (State Water Quality Control Board, 1964a). More recently, Grigg and Kiwala (1970) concluded that fine-grained, organic-rich material was adversely affecting benthic communities on the Palos Verdes shelf. Numbers of macroscopic species collected by divers along five transects were negatively correlated to abundance of the fine organic sediments. Amounts of the fine organics increased at stations near the Los Angeles County Sanitation Districts outfall so these authors inferred that effects noted were related to the discharge. They believed that settling fine-grained material has modified or covered substrates otherwise suitable for larval settlement of benthic species. Young (1964) described peculiarities among fauna of Palos Verdes (e.g. underweight condition, lesions). Resig (1960) reported that foraminiferal distributions showed influence of the discharge. An area northwest of the outfall yielded sediments containing H_2S and some stations within this region were devoid of live foraminiferans. Klein and Goldberg (1970) showed concentration gradients of mercury in the Palos Verdes sediments with a maximum near the outfall (at approximately the site

devoid of foraminifera according to Resig) and decreasing farther away from the terminus. Mercury content of three benthic organisms collected at Palos Verdes was quite variable but comparable to levels recovered from these species off a control area at La Jolla. Palos Verdes sea urchin populations have been studied extensively to assess influences of discharged wastes and it appears that the outfall does contribute to urchin nutrition here (Pearse et al., 1970). In summary, the Los Angeles County Sanitation Districts outfall system appears to have had a significant ecological impact at Palos Verdes. Resource losses outweigh gains by a substantial margin.

Santa Monica Bay

The extensive trawling survey conducted jointly by the City of Los Angeles and the Department of Fish and Game in Santa Monica Bay has been described above. Prior to the trawling, Hartman (1956 a,b) defined several faunal zones according to estimated influence of the Hyperion discharge. Groups utilized for this purpose were polychetes, starfish, and crustaceans. A zone limited by pollution extended for about half a mile from the outfall terminus. Other zones were labeled pollution tolerant, limited enriched, unlimited enriched, and unlimited diminished, in order of increasing distance from the discharge. Return to normality was judged to occur at a distance of six miles from the outfall. Physical and chemical features of the bay were discussed by Gunnerson (1958). Resig (State Water Quality Control Board, 1965a) found no barren areas in the bay when sampling forminifera, although she noted several

unusual distribution patterns. Klein and Goldberg (1970) studied sedimentary mercury concentrations of the bay and showed defined gradients decreasing at greater distances from the outfall terminus. In a review of recent sportfishing statistics for the bay, Bendix Marine Advisers (1970) noted a precipitous three year decline from 1966 to 1968 (more recent data were not available) and a decreasing long-term trend dating from 1949. The 1966-68 decline extended to all categories of fishes. Fishing effort also showed a marked drop during this period. In summary, Santa Monica Bay (which contains the second largest discharge on the Pacific coast) has revealed signs of change and even stress. Changes have not, however, been as extensive as documented for the Palos Verdes shelf (site of the largest discharge).

San Francisco Bay

Our literature review is primarily concerned with ecological conditions near waste disposal facilities discharging to the open sea so that bay pollution problems are not entirely relevant. San Francisco Bay, however, has been given so much att ntion that any description of marine pollution studies on the Pacific coast would be incomplete if a cursory treatment of the bay were omitted. Background conditions within the bay are probably better documented than any other California area. Information on bay fisheries antedates 1870 (*cf*. Skinner, 1962). The *Albatross* expedition of 1912-13 provided considerable data on the fauna (Sumner *et al*., 1914).

A series of publications by Filice (1954a, 1954b, 1958,

1959) correlated faunal distributions with proximity to waste disposal areas in the bay. This author identified three zones around waste disposal areas (barren, marginal, and normal). In the early 1960's, a very broad survey was conducted by the Sanitary Engineering Research Laboratory (SERL) of the University of California Berkeley. Like the Allan Hancock Foundation study in southern California, the SERL investigation examined many parameters to characterize physical, chemical, geological and biological characteristics of the bay. Initially, attempts were made to identify microplankton to species. This objective was discontinued and the reasons given (Sanitary Engineering Research Laboratory, 1964) should be noted by all who would attempt large-scale plankton surveys.

> "It is nearly impossible to identify the microplankton species in preserved samples since the preservative used in this study (formalin) destroys many of the delicate features needed for species identification. For this reason, duplicate microplankton samples were collected during a number of cruises made during the spring of 1963. One sample was analysed using the regular procedures employed in this investigation and in the second sample enumeration and identification were made directly of the live microplankton as soon after collection as practicable. Most of the live plankton were identified as to species. However, it was soon apparent that the two methods of counting and identifying gave radically different distributions of organisms. Often genera identified and counted by one procedure would be missing completely when using the other procedure. Since the distributions differed so greatly it was decided that identification of live samples would not aid significantly in the species identification in the preserved samples. Consequently the work on live samples was abandoned."

Consequently, commonest diatoms and two dinoflagellates were identified to genera while zooplankton were characterized only to higher taxa. Only general analyses were attempted (i.e. seasonal abundance changes, distribution within broad regions

of the bay such as Suisun Bay, San Pablo Bay, etc.). Correlations with specific waste discharges were not attempted. The diatom genus *Skeletonema* occurred throughout the bay, generally ranking between 5th and 7th among the 32 diatom genera identified (ranked according to frequencies). The study was able to identify an unusually high percentage of benthic organisms to species. The tabulation for Central San Francisco Bay, for example, totaled 102 groups of which 85 represented species identifications. Analysis of the benthos included frequency tabulations and diversity estimates by station grouped within principal subregions of the bay (*i.e.* Suisun Bay, San Pablo Bay, etc.). For Central San Francisco Bay, highest diversity occurred near the Golden Gate. Diversity declined as distance from the Golden Gate increased. Probably this pattern resulted from intermixing of bay and oceanic species near the Golden Gate. Gradual loss of the oceanic forms farther in the bay caused a declining gradient in diversity. No correlations were made between benthic animal distributions and specific waste discharges. Discharge volumes into the central bay area totalled about 200 mgd at this time.

The SERL survey was partially duplicated in 1968 by Engineering-Science Inc. as subcontractor to Kaiser Engineers for the San Francisco Bay-Delta Water Quality Program. A primary objective of the Biologic-Ecologic portion of the study (Task VII-1b) was to compare conditions in 1968 with data collected five years previously by SERL and define changes and trends. The conclusions were lengthy and cannot even be

summarized here. It should be noted, however, that perhaps the most important conclusion ("Toxicity now exerts a major influence on the health of biological populations in the bay", Kaiser Engineers, 1968) does not seem adequately justified. The statement appears to be based on changes found in diversity of sedimentary infauna. The diversity index used was not the same as employed for the SERL study. The index was apparently formulated specifically for this investigation as it did not correspond to more conventional diversity indices described in ecological literature. This index appears to be a modification of a prominence index. and the theoretical justification for its use as a diversity index is not clear. The Kaiser report recalculated the SERL data (Sanitary Engineering Research Laboratory, 1964, 1965) using their novel diversity-prominence index, identifying mean as well as 20 and 80 percentile values. Comparing the 1968 data to the recalculated SERL data, 6 of the 16 diversity-prominence values found in 1968 (i.e. 37.5%) fell below the 20 percentile level of the SERL data. Only one of the six, however, was substantially below, and most were borderline cases. Thus the case for concluding that toxicity effects had increased to major proportions in San Francisco Bay between 1963 and 1968 does not seem strongly convincing.

Puget Sound

Wilson (1958) analyzed 40 grab samples of sediment from the vicinity of the North Trunk outfall (35 mgd dry weather flow) and 4 samples off the Piper Creek outfall (1.4 mgd dry weather flow) in Puget Sound. Organisms were removed by seiving

through 40 mesh screen, counted, and usually identified to order but occasionally to species. Presence or absence of sludge was noted. Polychetes, amphipods, and isopods were abundant near the outfall terminus. Many freshwater oligochetes and nematodes also occurred in the sludge-enriched samples and were believed to have been introduced directly from the effluent. At distances of more than 1000 feet from the terminus, sludge was encountered only in depressions (Figure 5). Ostracods, decapods, cirripedia, mollusks, echinoderms, and lesser phyla entered samples sparsely when sludge was absent. Abundances of polychetes, amphipods, and isopods also tended to be low in the sludge-free samples. Bull kelp (Nereocystis) and eel-grass (Zostera) patches occurred within the study areas (Figure 5) and were apparently not inhibited by either suspended or sedimented sludge. The North Trunk outfall discharged untreated sewage at a depth of 40 feet. The study is interesting in revealing conditions very close to a moderate-size discharge. Most of the other studies we have cited have not paid much attention to immediate vicinities of outfalls because these areas are normally considered as mixing and dilution zones where adverse effects are expected and tolerated but not investigated carefully.

Summary of Biological Studies near Outfalls

Marine waste disposal by means of submarine outfalls has been practised on the Pacific coast since the nineteenth century. Ecological effects have been studied extensively. Effects on plankton are moderate and usually involve growth stimulation.

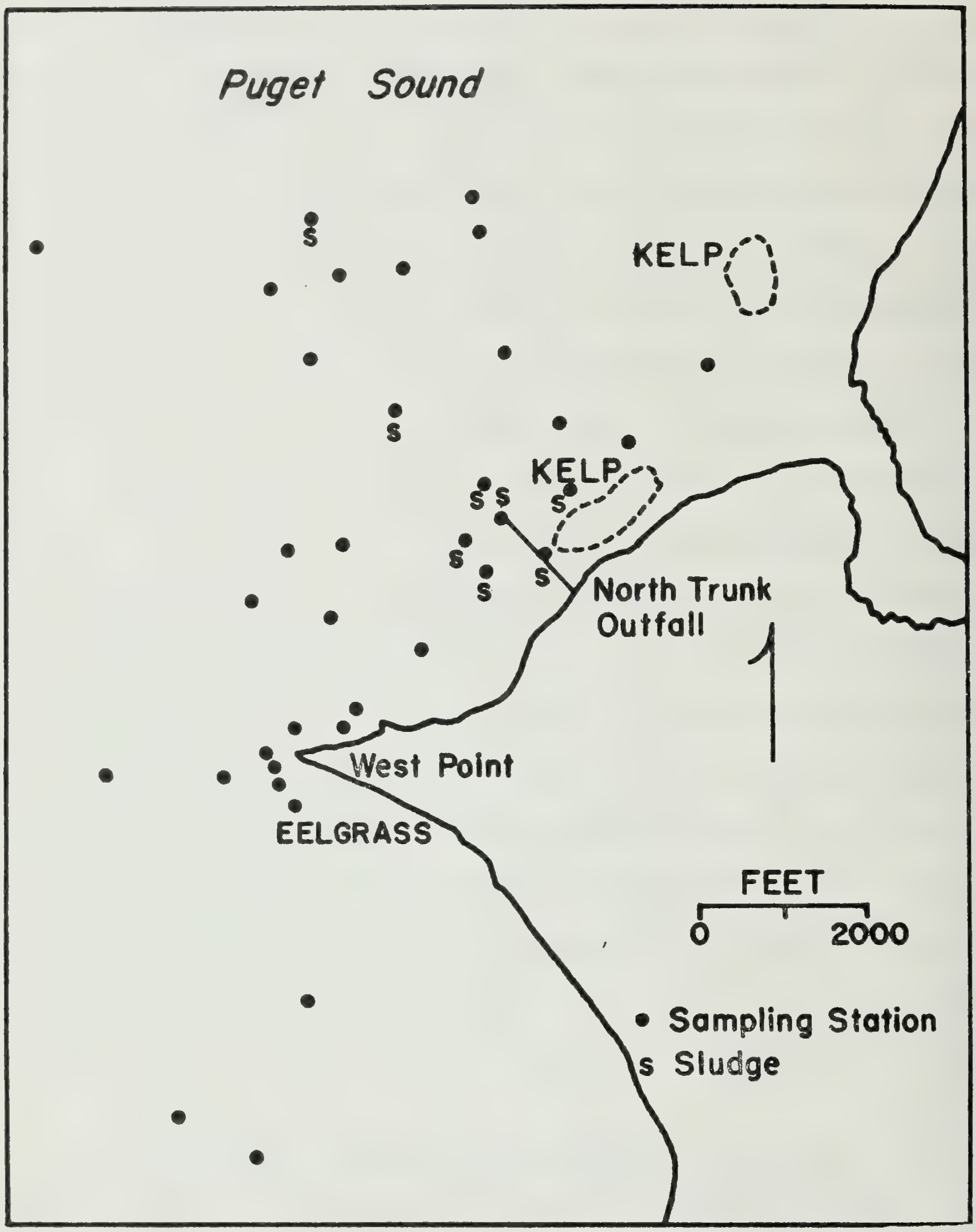

Figure 5. Sampling stations used by Wilson (1958) to evaluate biotic distributions near North Trunk outfall. Sludoe suspensions were noted in nearby kelp (Nereocystis leutkeana) and eelgrass beds.

No correlations have been found between sewage disposal and plankton blooms. When large discharges are situated near rocky substrate, encouragement of sea urchin populations by the wastes can affect communities associated with attached plant life. The urchins graze away all plants and are then partially nourished by organics from the outfall. Urchin control techniques have been developed to restore the ecological balance. Small discharges of five to ten mgd apparently do not encourage urchins significantly. Diluted sewage effluents can stimulate growth of attached algae.

Open sea discharges less than 100 mgd over sedimentary bottoms can cause faunal enrichment (except perhaps within restricted dilution zones near the terminus). Discharges of about 200 mgd or more can create adjacent zones of significant impoverishment. For large discharges over sedimentary bottoms the impoverishment may be related to sludge accumulation. For large discharges over rocky bottom impoverishment may result from thin deposits of fine organic-rich sediment that interferes with settling by larvae of species requiring hard substrate for attachment.

SECTION III

REVIEW AND ANALYSIS OF LITERATURE RELATING TO FISHERIES OF THE SAN FRANCISCO COAST

Although fauna and flora of San Francisco Bay and Delta have been studied exhaustively and are described by a voluminous literature, the coastline off San Francisco and the Gulf of the Farallones has apparently received scant attention. A mimeographed report by Ebert and Cordier (1966) describes a diving and sampling survey off Seal Rocks. Statistical information on commercial and recreational fish catches is gathered by the Department of Fish and Game and summarized annually in their Fish Bulletin series. A portion of this information relates to the San Francisco region. Odemar *et al.* (1968) analyzed the catch data for the region Point Arena to Point Lobos in considerably greater detail than provided by the Fish Bulletin summaries. Miller & Gotshall (1965) described ocean sportfish catch and effort for State Fisheries north of Point Arguello. Their statistics, however, usually represented broad coastal areas. Young (1967) presented detailed useful statistics on sportfish catches for specific areas.

The Department of Fish and Game collates catch information by area of origin. The coastal waters are subdivided by a grid into squares approximately ten miles per side. Data are grouped according to squares where fishes are caught. There are almost a thousand squares for the entire State. The annual Fish Bulletin summaries group data from the squares into six large regions and do not ordinarily provide information for each square. The regional area of interest for us is called the San Francisco Area and embraces

the coasts of Sonoma, Marin, San Francisco, and San Mateo Counties as well as San Francisco Bay. Odemar _et al._ (1968) have provided some of the data for statistical squares in the San Francisco Area for the period 1962 to 1966. The square of particular concern for our analysis is numbered 455 (Figure 6). This square embraces a territory from the north side of the Golden Gate entrance westward about one-third the distance to the Farallones and southward about half way to Pillar Point.

Many factors can influence fish catches. Some factors arise naturally: fluctuations in abundance, changes in distribution, changes in the physical climate (e.g. temperature). Other factors are of human origin: improvements in fishing gear or methods, changes in preference, changes in regulations controlling fishing. It is often helpful to relate fish catches from a given site to catches for a larger region to ascertain whether a fluctuation is a purely local phenomenon or represents a broad-scale change. In general our analyses will compare San Francisco Area catches with State-wide catches. Simple disturbances can affect a fishery for several years. Consequently periods of ten to twenty years should be studied for defining valid trends. For most of our temporal analyses we have examined data from the years 1953 to 1968 (Dept. of Fish & Game, 1956, 1958, 1960a, 1960b, 1961, 1963, 1964, 1965a, 1965b, 1967, 1968a, 1968b, 1970). By 1953, fluctuations arising from World War II had subsided. The latest year for which fishing statistics are available is 1968.

The Combined Commercial Fisheries

Recent Fish Bulletin annual summaries employ 41 categories to subdivide catch statistics from the San Francisco Area (_cf._ Department of Fish and Game, 1968b). Most of these categories

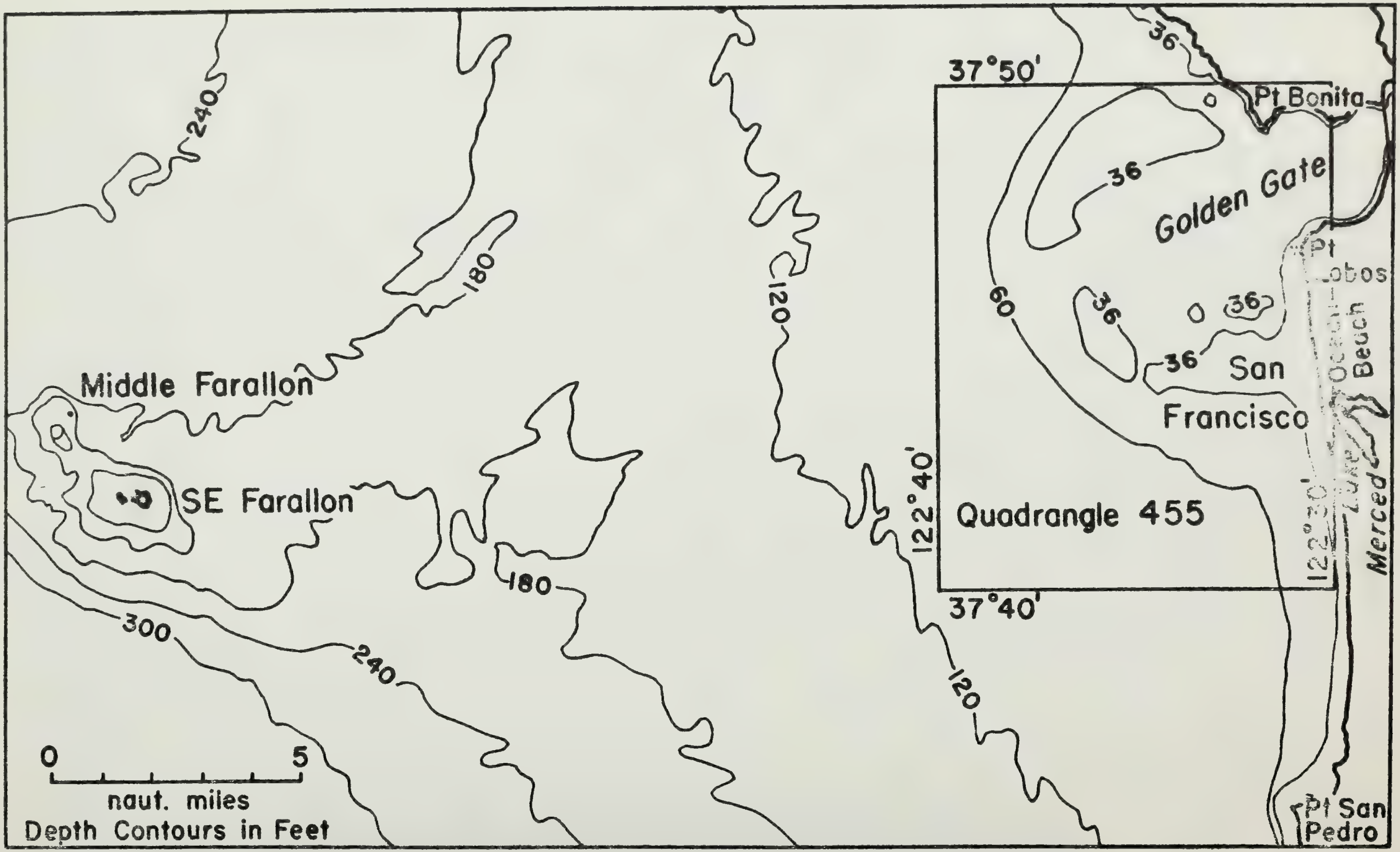

Figure 6. Cross section of Gult of the Farallones, showing location of Square 455 (actually a quadrangle) which is a section of an orid used by the Department of Fish and Game for subdividing the California coast. The proposed outfall would probably discharge close to the center of Square 455.

represent individual species (e.g., English Sole, California Halibut). Some of the categories, however, are aggregates of fairly minor species (e.g., miscellaneous sole, perch). Combined totals from all 41 categories reveal a downward trend for the San Francisco Area during the period 1953 to 1968 (Table 5, Figure 7). Comparison with statewide totals shows rather little correlation. The San Francisco decline is more pronounced than the statewide values (compare mid-1950's with late 1960's). It is important to understand the basis for these declines, particularly for the San Francisco area. Without such an understanding we would be in a poor position to evaluate whether the proposed discharge into the Gulf of the Farallones might add stress to an already stressed situation.

Within the period examined, both San Francisco and the statewide combined fisheries lost a major component. Market crab harvests from San Francisco declined seriously after 1958 (discussed in greater detail below). At the statewide level, the sardine fishery also collapsed following 1958. Subtracting crab harvests from San Francisco totals and sardine catches from statewide totals still yields a definite declining trend for San Francisco (although not as marked as noted for the total catch; Table 5), whereas the slight decline in statewide figures disappears (Table 6, Figure 7).

Detailed inspection of San Francisco Area statistics revealed a stable component and a variable component. The variable component was composed of pelagic fishes (primarily anchovy, herring, and albacore). Pelagic fish abundances may vary greatly at a given site due to ocenaographic vagaries and migratory capabilities of many species. The total populations, however, within a larger area

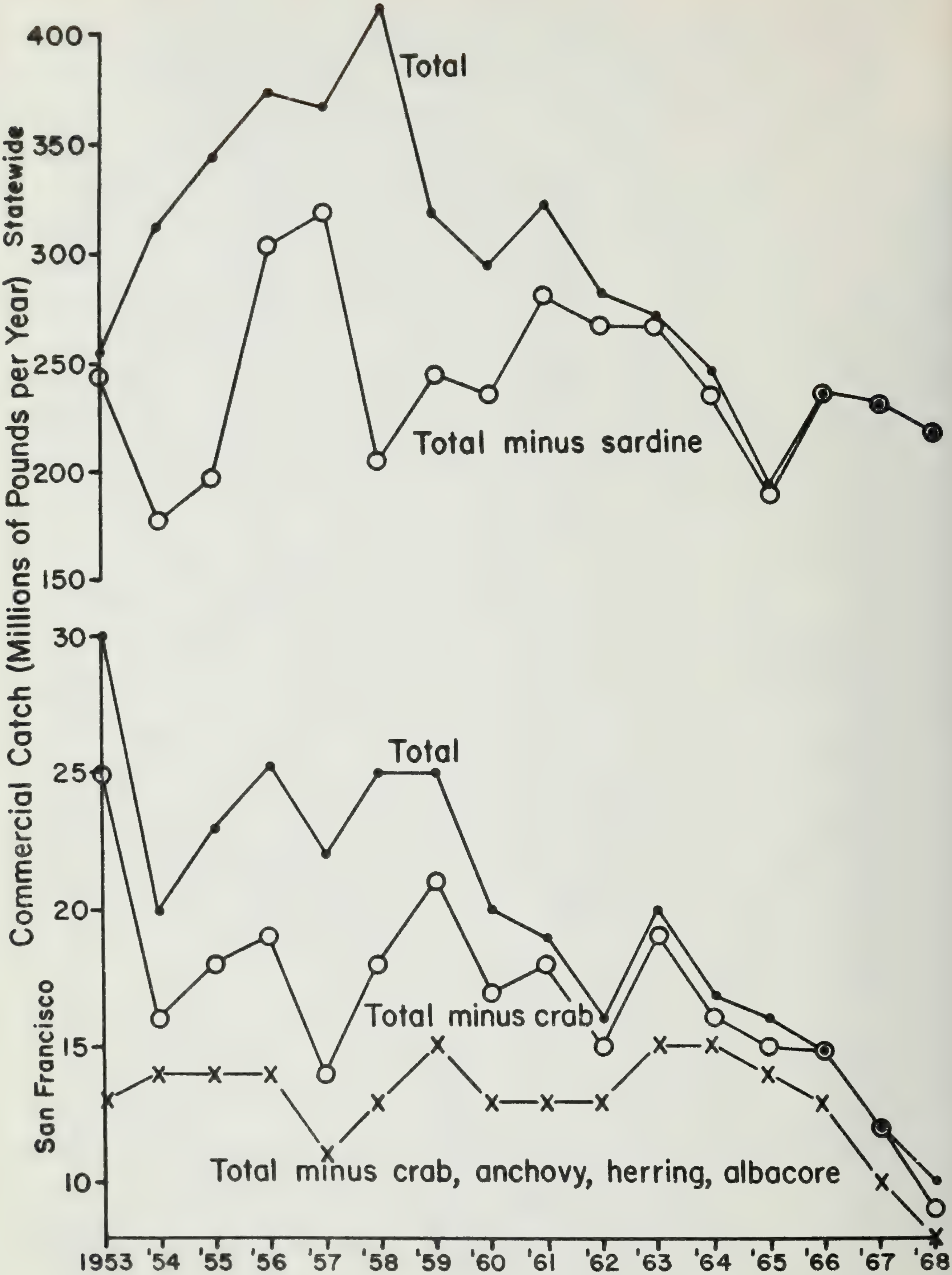

Figure 7. Annual Statewide and San Francisco Area commercial fish catches for the 16 year period 1953 to 1968. As shown, certain components were subtracted from the totals to identify causes of declining trends.

TABLE 5

Comparison of commercial catch statistics for the San Francisco Area with statewide totals for 1953 to 1967. Figures represent millions of pounds per year and include only catches from California waters. Data from Dept. of Fish and Game Fish Bulletins.

Year	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68
San Francisco	30	20	23	25	22	25	25	20	19	16	20	17	16	15	12	10
All California	254	312	344	374	367	412	319	294	322	282	271	247	192	236	231	218

TABLE 6

Comparison of total San Francisco Area commercial fish catches minus take of market crab with statewide totals minus take of sardine. Figures represent millions of pounds per year and include only catches from California waters. Statistics from California Dept. of Fish and Game Fish Bulletins.

Year	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68
San Francisco minus crab	25	16	18	19	14	18	21	17	18	15	19	16	15	15	12	9
Statewide minus sardine	244	178	197	303	320	204	244	235	279	266	264	234	190	235	231	218

(e.g. east Pacific waters) nonetheless might remain constant. Subtracting anchovy, herring, and albacore catches as well as crab harvests from the San Francisco Area totals, eliminates the long term declining trend (Table 7, Figure 7). The result is a record that flucturates modestly around a mean level of 13 million pounds of fishes per year. Two major dips occurred in 1957 and 1967-68. Primary causes for these dips were reductions in salmon catches as well as the principal species collected by otter trawling in water 600 feet or deeper (dover sole, petrale sole, rockfishes, sablefish).

In summary, for purposes of analysis, the combined commercial fisheries of the San Francisco Area during the period 1953 to 1967 may be divided into three major groups. These are:

1. The stable group; this assemblage contains one species that is semi-pelagic (salmon) but is mainly comprised of benthic animals harvested primarily by trawling.
2. The pelagic fishes; this group has been in a declining trend within the San Francisco Area during the past fifteen years.
3. The crab fishery; this fishery resembles the pelagic group in its recent decline in the San Francisco Area. It is, however, a benthic fishery, so it seems best to create a separate group for this assemblage.

In order to examine the contributions of these groups to stability or decline of San Francisco Area fisheries, we will describe in greater detail the fluctuations that have occurred among the species involved.

TABLE 7

Total San Francisco Area commercial fish catches minus catches of market crab, anchovy, herring, and albacore. Figures represent millions of pounds per year. Statistics from California Dept. of Fish and Game Fish Bulletins.

Year	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68
	13	14	14	14	11	13	15	13	13	13	15	15	14	13	10	8

Principal Components of the Commercial Fishery

The Stable Group

The 1967 Fish Bulletin summary of the California fish catch (Department of Fish and Game, 1968b) lists 23 ocean species that fall into the stable group but we will not consider eight of these (cabezon, white croaker, arrowtooth flounder, perch, pompano, misc. sole, abalone, and octopus) because they are usually negligible in the total catch. Catches of certain species (e.g. salmon, dover sole, etc., Table 8) tend to fluctuate somewhat more than the fairly stable total for this group. The overall stability probably benefits from the large number of species in the group. Even large abundance changes in one species usually affects the yearly total only modestly and may be offset by opposite changes in another species. The total sixteen-year catch was also computed for each species to provide an estimate of relative importance. Dollar values for 1966 catches (from Odemar *et al.*, 1968) are also listed as an alternate assessment of relative importance. Ranking by dollar value corresponds fairly closely to ranking by fifteen-year catch but the large dollar value preponderance of salmon is noteworthy, arising from the high price the species commands.

The short term decline in this group commencing in 1966 results primarily from decreases in salmon, dover sole, petrale sole, rockfishes, and sablefish catches. The dip in salmon is within the normal range of previous fluctuations. The other categories are caught in deep water and would not be expected to be influenced by a shallow water outfall.

TABLE 8

Sixteen-year catch records for principal components of the Stable Group Fisheries (as defined in the text) of the San Francisco Area. Figures represent millions of pounds per year. Catch data from Dept. of Fish and Game Fish Bulletins, dollar values from Odemar et al. (1968).

Species	'53	'54	'55	'56	'57	'58	'59	Year '60	'61	'62	'63	'64	'65	'66	'67	'68	16 year total	1966 dollar value $X 10^{-3}$
Salmon	3.3	3.4	3.9	2.9	1.3	1.7	4.6	2.9	2.7	2.1	3.5	3.5	3.6	2.2	1.8	2.2	46.6	$1279
Rockfish	4.2	3.0	1.6	2.9	2.8	4.2	4.9	3.3	2.2	2.0	2.4	1.8	1.6	1.6	0.9	0.6	40.2	105
English sole	*	*	2.3	1.7	1.6	1.5	1.0	0.7	1.3	2.2	1.9	2.0	2.0	1.9	1.9	1.7	23.7*	171
Dover sole	*	*	0.5	1.1	0.5	1.0	0.8	1.5	1.4	1.5	2.0	2.7	2.6	2.5	1.3	0.3	19.7*	144
Petrale sole	*	*	1.6	0.9	0.7	0.7	0.8	0.6	0.8	0.9	0.9	1.0	0.9	1.1	0.8	0.5	12.2*	157
Sablefish	0.2	0.4	0.4	0.8	0.4	0.5	0.7	0.8	0.7	0.9	0.8	0.8	0.7	1.0	0.5	0.1	10.7	42
Rex sole	*	*	0.5	0.5	0.4	0.4	0.5	0.5	0.4	0.5	0.5	0.5	0.5	0.4	0.3	0.2	6.1*	31
Sanddab	0.3	0.4	0.3	0.4	0.4	0.5	0.3	0.2	0.2	0.2	0.3	0.4	0.2	0.3	0.2	0.3	5.1	23
Lingcod	0.2	0.2	0.3	0.3	0.3	0.5	0.4	0.4	0.4	0.3	0.3	0.3	0.2	0.3	0.2	0.2	4.8	24
Flounder	0.2	0.2	0.4	0.2	0.3	0.3	0.2	0.1	0.1	0.1	0.3	-	0.2	0.2	0.4	0.2	3.4	15
Ocean Shrimp	-	0.1	0.3	0.3	0.5	0.2	-	0.1	-	0.2	0.2	-	0.2	-	-	0.2	2.3	15
Shark	0.1	0.1	0.1	-	0.1	0.1	0.1	0.1	0.1	0.2	0.2	0.1	0.1	0.1	0.1	0.1	1.7	5
Skate	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.6	1
Turbot	-	0.1	0.1	0.1	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	1.4	3
Calif. halibut	-	-	-	-	-	-	0.1	-	0.1	-	0.1	0.2	0.2	0.2	0.3	0.2	1.2	59
Yearly total	12	13	12	12	9.4	12	15	11	11	11	13	13	13	12	8.9	7.0	180.7	

* Sole catches not broken down to species until 1955, therefore totals only represent thirteen years. All sole catches for 1953 were 3.2; for 1954, 4.8.

Pelagic and Crab Fisheries

The 1967 Fish Bulletin summary of the California fish catch (Department of Fish and Game, 1968b) lists eight ocean species from the San Francisco Area that fall into the pelagic classification but we will not consider three of these (bonito, jack mackerel, and whitebait smelt) because they contribute to the group only in minor ways. To estimate relative importance we have again listed sixteen year totals for catches as well as dollar values for the 1966 catch (Table 9). Albacore is clearly the most important fishery. The general decline in the group during our sixteen year study period was due primarily to decreases in herring and anchovy takes, although there was also a less drastic recent decline in albacore.

Trends apparent in the albacore and herring records from San Francisco are also present in the statewide statistics, hence may represent very broad scale fluctuations unrelated to events in the San Francisco Area (Table 9). San Francisco and statewide anchovy records, however, differ substantially. If we eliminate 1953 from consideration as possibly an abnormal year, the anchovy fishery is seen to be quite minor at San Francisco. The statewide yearly totals for the five pelagic species considered yield a fairly stable record and do not reflect the decline apparent in the San Francisco totals. Fluctuations among albacore, herring, and anchovy catches are often opposing, producing a fairly stable statewide total.

The San Francisco market crab fishery is fairly similar to the statewide total (Table 9) except that the decline centering around 1963-1964 in statewide figures has extended for a much longer time at San Francisco. Curiously, recovery from this decline by statewide market crab catches closely resembles recovery during the

TABLE 9

Sixteen year catch records for principal components of the Pelagic Fishes Group and of the Crab Fishery for the San Francisco Area and for all California waters. Only those pelagic fishes important in the San Francisco Area are considered. Figures represent millions of pounds per year. Catch data from Dept. Fish and Game Fish Bulletins, dollar values from Odemar et al. (1968).

	Year																	
Species	'53	'54	'55	'56	'57	'58	'59	'60	'61	'62	'63	'64	'65	'66	'67	'68	16 yr. total	1966 dollar value X 10^{-3}
							Pelagic Fishes Group - San Francisco Area											
Albacore	4.2	1.2	2.5	3.2	2.5	2.9	3.6	3.0	3.9	1.5	3.4	1.3	0.6	1.4	1.5	1.0	37.2	$256
Herring	4.8	0.5	1.1	0.9	0.5	1.6	1.4	1.4	1.0	0.8	0.4	-	-	-	-	0.1	14.5	2
Anchovy	3.1	0.3	0.2	0.4	-	-	-	-	0.2	-	-	-	0.1	0.1	-	0.1	4.5	3
Smelt	0.2	0.3	0.4	0.2	0.1	0.1	0.1	-	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1	2.2	12
Hake	-	-	-	-	-	-	-	0.1	-	0.1	0.1	-	-	-	-	-	0.3	0.6
Yearly total	12	2.3	4.2	4.7	3.1	4.6	5.1	4.5	4.7	2.5	4.0	1.4	0.8	1.6	1.6	1.3	58.7	
							Pelagic Fishes Group - Statewide											
Albacore	13	14	9	16	23	25	33	32	21	32	42	34	20	16	15	12	357	
Herring	8	9	19	17	12	24	17	18	14	13	6	4	5	2	3	-	169	
Anchovy	85	42	45	60	41	12	7	5	8	3	5	5	6	62	70	31	418	
Smelt	1	1	1	-	-	1	1	-	-	-	-	-	-	-	1	-	6	
Hake	-	1	1	1	1	1	1	-	-	-	-	-	-	-	-	-	6	
Yearly total	107	67	75	94	77	63	49	45	43	48	53	43	31	80	89	43	956	
								Market Crab Fishery										
S.F. Area	4.1	4.0	4.4	6.0	8.6	7.4	3.9	3.4	1.1	1.3	1.2	0.8	0.5	0.3	0.9	0.8	48.7	118
Statewide	8.2	7.8	6.1	14	19	17	17	15	12	3.2	1.9	1.8	4.8	12	12	16	168.4	

same period by the statewide anchovy catches. Crabs have a long pelagic larval stage. Perhaps larval success in the plankton controls adult abundances and the fishery consequently follows patterns characteristic of pelagic groups rather than the relatively stable records typifying benthic fisheries. Clearly the unique features of the crab fishery merit additional consideration and we will discuss the species below when considering possible ecological affects of a discharge in the Gulf of the Farallones.

The Sportfishery

Detailed published statistics for sportfisheries are somewhat less complete than for commercial fisheries. The annual Fish Bulletin summaries list statewide partyboat catches for eighteen categories with no breakdowns according to lesser areas of origin. These Bulletins have given ocean recreational salmon landings by port, month, and species for both partyboat and skiffs, since 1962. Publications on certain groups, species, or fisheries often provide fairly detailed information about fishes of recreational interest. The works by Young (1969) and Odemar *et al*. (1968) offer considerable data relating specifically to the San Francisco area. Additional data are given by Miller and Gotshall (1965) although their findings were generally related to broad stretches of coastline.

Odemar *et al*. (1968) list 113 species in a tabulation of the total 1966 sportfish catch from Golden Gate to Point Lobos in Monterey County. The great majority of these were quite minor components. The sportfisher can be subdivided according to the location or platform used by the fisherman (*i.e.* pier, shore, partyboat, skiff). The principal ocean-fishing effort in San Francisco County is conducted

from shore (approx. 25% of the effort) and from partyboats (approx. 75% of the effort; Odemar _et al._, 1968). There is also a small salmon fishery operating from skiffs.

Young (1969) summarized annual partyboat catches for twelve categories from the ports of San Francisco, Richmond, Sausalito, San Rafael, Tiburon, Oakland, Berkeley, Alameda, and Redwood City. These statistics apparently include catches from within the Bay and it is not always possible to segregate ocean-caught fishes (although some of the species are more likely to have originated from the ocean).

Young's data for the fifteen year period 1953 to 1967 indicate that relative importances of his major categories were (in descending order) salmon, rockfish, striped bass, lingcod, jack mackerel, California halibut, white croaker, cabezone, and flatfish (Table 10). Striped bass totals after 1959 included fish caught in the Bay and ocean; prior to 1959, only ocean-caught individuals were tallied. As there were no striped bass landed from the ocean between 1953 and 1959, the importance of this species in the oceanic portion of the sportfisheries is open to question.

Odemar _et al._ (1968) segregated the Bay-originating average annual striped bass catches by partyboats from ocean-originating catches (_i.e._ mainly from the Gulf of the Farallones) for the period 1962 to 1966. Gulf of Farallones catches averaged 4119 striped bass per year vs. 28,964 fishes per year from the Bay. Assuming the same proportion of ocean vs. Bay striped bass catches for the years 1960, 1961, and 1967, the total for the striped bass fishery in Table 10 would be adjusted to 35,000 fishes as being caught in the Gulf of the Farallones. The alteration thus does not change the rank of this

TABLE 10

Fifteen year records for principal components of partyboat catches from the ports of San Francisco, Richmond, Sausalito, San Rafael, Tiburon, Oakland, Berkeley, Alameda, and Redwood City. Figures represent thousand of fishes. Data from Young (1969). We have adjusted total fifteen year catches in the bottom row to eliminate catches of Bay origin for species where information is available.

Year	Salmon	Striped Bass	Rockfish	Flatfish	Lingcod	Cabezon	Calif. Halibut	White Croaker	Jack Mackerel
1953	85	-	8	0.506	0.832	0.335	0.013	0.297	0.148
1954	101	-	8	0.759	0.926	0.437	0.274	0.083	0.075
1955	88	-	3	0.060	0.649	0.068	0.017	0.146	0.042
1956	63	-	4	0.439	0.958	0.079	0.160	0.468	0.019
1957	26	-	9	0.271	2.150	0.339	0.126	0.055	0.004
1958	45	-	84	0.417	2.933	0.405	0.107	0.600	3.474
1959	48	-	20	0.175	1.270	0.181	0.005	0.279	1.116
1960	30	29	8	0.035	0.309	0.053	0.109	0.254	2.369
1961	33	41	12	0.092	1.066	0.129	0.554	0.169	1.399
1962	75	39	28	0.200	2.239	0.386	0.676	0.327	2.417
1963	63	56	36	0.237	3.556	0.642	2.056	0.741	3.068
1964	76	24	15	0.378	1.685	0.249	3.054	0.367	0.425
1965	45	11	53	0.429	3.887	1.139	0.602	1.064	1.570
1966	62	31	80	0.714	5.021	0.500	1.265	0.370	0.754
1967	78	12	51	0.974	1.888	0.753	0.646	1.270	0.564
Total	918	243	419	5.7	29.4	5.7	9.7	6.5	17.4
Adj. Total	918	35	388	no data	29.4	no data	no data	no data	no data

species. Similar adjustments can be made for other species to eliminate Bay-caught individuals, using data from Odemar et al. (1968). Adjustments for salmon and lingcod were negligible while a reduction of 7.5% for the rockfish total was indicated. No changes in ranking resulted from these adjustments (Table 10).

The skiff fishery of the San Francisco Area recovers considerably smaller yields than partyboat activities (skiffs are private or rented craft not carrying paying passengers and not fishing commercially). Consequently the only catch data available are for salmon (presumably the largest component of the skiff fishery). Data from 1962 to 1968 indicate salmon catches from skiffs ranged from 3.5% to 17.5% of partyboat totals (Table 11).

A small shoreline fishery exists along the outer San Francisco coast. Odemar et al. (1968) reported that 6,152 striped bass were caught by surf fishermen in 1966 between the Golden Gate and Point Lobos (in Monterey County) "most of which were caught off San Francisco and San Mateo County beaches". Flatfish, surfperches, white croaker, dogfish, greenling, and certain rockfishes were also important surfishery components of the Golden Gate-Point Lobos region, but catches for San Francisco County were not given. Odemar et al. (1968) state "most of the effort occurred in San Mateo County, followed by Monterey, Santa Cruz, and San Francisco Counties".

SUMMARY

Total commercial fish catches for the San Francisco Area exhibited a long-term decline, dating from 1953 or earlier. Causes were decreases among pelagic fish and market crab catches. Fluctuations among major pelagic fishes were probably related to broad-scale phenomena and not to any local adverse changes in the San Francisco region. Causes of the market crab decline remain a

TABLE 11

Comparisons of partyboat and skiff catches of silver and king salmon for the San Francisco area. Figures indicate numbers of fishes. Data from California Department of Fish and Game Fish Bulletins.

Year	Species	Partyboat	Skiff	Total
	King	75,071	1,640	77,711
1962	Silver	41	0	41
	Total	75,112	2,640	77,752
	King	62,469	3,708	66,177
1963	Silver	1,062	273	1,335
	Total	63,531	3,981	67,512
	King	70,571	3,584	74,155
1964	Silver	7,895	427	8,322
	Total	78,466	4,011	82,477
	King	43,006	2,707	45,713
1965	Silver	2,784	177	2,961
	Total	45,790	2,884	48,674
	King	59,953	4,409	64,362
1966	Silver	3,137	69	3,206
	Total	63,090	4,478	67,568
	King	55,526	2,977	58,503
1967	Silver	16,891	1,099	17,990
	Total	72,417	4,076	76,493
	King	106,839	16,698	123,807
1968	Silver	7,274	2,847	10,121
	Total	114,113	19,815	133,928

mystery, particularly as the statewide fishery recently improved. A short term decline dating from 1966 was primarily caused by decreases in the deep water trawling fisheries.

Principal components of San Francisco commercial ocean fisheries include salmon, rockfish, english sole, dover sole, petrale sole, sablefish, rex sole, sanddab, lingcod, flounder, ocean shrimp, shark, skate, turbot, California halibut, albacore, herring, anchovy, and market crab.

Principal components of the ocean sportfishery off San Francisco are salmon, rockfish, striped bass, and lingcod with jack mackerel, California halibut, white croaker, surfperch, cabezone, and various other flatfish playing lesser roles. These conclusions regarding principal components generally agree with statements by Odemar et al. (1968) and with the list of principal commercial and sportfish species for the San Francisco Bay area counties in the inventory published by the California Fish and Wildlife Plan (Dept. of Fish and Game, 1965c).

SECTION IV

POSSIBLE INTERACTIONS BETWEEN SAN FRANCISCO FISHERIES AND AN OCEAN OUTFALL

An ocean outfall into the Gulf of the Farallones would presumably originate centrally from the coastal area off the City and would discharge perhaps one to three miles offshore over a sedimentary bottom into extremely turbulent water. Excellent mixing can be expected and sludge accumulations would almost certainly be negligible. Discharged wastes under these circumstances might conceivably have the following influences on surrounding biota.

1. Suspended and dissolved organics might nourish certain species, increasing their survival capabilities and causing abundance increases. Such changes probably would also affect food chains based on such favored species. Possibly less-favored species might decline due to alterations in competition or control relationships.

2. Discharged toxicants might affect nearby sensitive species within limited areas.

3. Concentrations of substances with slow biodegradability might increase among resident fauna.

4. Strange tastes or odors might cause pelagic fishes to shun the area or inhibit planktonic larvae from settling.

As indicated in our descriptions of conditions near the San Diego outfall (a discharge approximately the same size as contemplated for San Francisco) detailed studies have not revealed substantial deterioration of biota or natural communities near the discharge area. The closest monitoring stations at San Diego lie a mile from the discharge. To be extremely conservative, we will

identify principal marine resources presently existing within five miles of the proposed San Francisco outfall and then discuss how these organisms might be affected by the four mechanisms listed above. To be conservative we must also consider other fisheries for the general San Francisco area and be sure the proposed outfall would cause no significant impact upon them.

Principal Marine Resources within Five Miles of the Proposed San Francisco Outfall

Statistical square 455 in the grid used by the Department of Fish and Game (Figure 6) encloses all ocean bottom lying within five miles of the proposed San Francisco outfall, as it is conceived in preliminary design phases. Catch data for this square would, therefore, identify the most important fisheries closely associated with the territory.

Odemar *et al*. (1968) give 1962-1966 averages for Square 455 for many of the fisheries. This area was second only to San Francisco Bay as a source of striped bass. Square 455 also lies centrally within prime fishing areas for salmon and market crab. Considerable sportfishing effort is expended within Square 455. The area ranked fifth in partyboat average annual angler days from 1962 to 1966, considering all 129 squares lying between Point Arena and Point Lobos. Additional partyboat rankings for Square 455 vs. all 129 squares were: salmon 5th; lingcod 14th; rockfish 22nd.

Other marine resources from Square 455 were of lesser importance. Commercial catches of english sole were higher in 29 of the 129 squares than in Square 455. Within the Gulf of the Farallones the most productive fishing areas lie in depth ranges of 120 to 300 feet (i.e. deeper than Square 455), but nonetheless some english sole are taken in Square 455 (Odemar *et al*., 1968). No

ranking attempt was made for commercial catches of Dover sole, petrale sole, rex sole, sand sole, sablefish, sanddab, ocean shrimp, and California halibut as all these species were generally caught in other waters within the Gulf of the Farallones. Odemar et al. (1968) state that 98 percent of the anchovy catch in the region from Point Arena to Point Lobos originated from Monterey Bay. Undoubtedly anchovy are present in the Gulf of the Farallones and provide some dietary support for larger important predators such as salmon, striped bass, and albacore. We have noted above that the San Diego bait fishery (including anchovy) showed general association with sewage receiving areas, and would not expect that a discharge into the Gulf of the Farallones would adversely affect anchovy. No information was available on distribution of flounder, shark, skate, or herring catches. In any case, these four groups do not represent major fisheries in the San Francisco area.

The marine resources of primary concern in Square 455 are thus salmon, striped bass, market crab, and to a lesser extent, lingcod, rockfish, and english sole. Some albacore are taken in the Gulf of the Farallones but, as will be shown, any influence by a discharge on this resource would be trivial. Additionally the area contains many animals having no direct recreational or commercial values but nonetheless playing vital roles in the food chains and communities of which these fishes are a part, and thus indirectly contributing to the welfare of local fisheries. It is, therefore, pertinent to review briefly food habits and general biology of the species important in Square 455 fisheries in connection with possible influences of discharged wastes.

Salmon

King salmon (Oncorhynchus tshawytscha) is the most important salmon species in the San Francisco area, being three to 2000 times as plentiful in sportfish catches as silver salmon (Oncorhynchus kisutch, Table 11).

Salmon are anadromous fishes, moving into freshwater streams to spawn when mature. Adults die after spawning. The young migrate downstream after hatching and spend most of their three-to-seven year lifespan in the sea. Large numbers of salmon use San Francisco Bay as a pathway to and from their spawning grounds. If sewage-seawater mixtures affect salmon directly (toxicities, buildup of non-biodegradables, adverse odors or tastes, etc.), construction of the proposed outfall into the Gulf of the Farallones should not cause any changes because salmon have encountered these same wastes for many years while passing through San Francisco Bay. It is more likely that any such direct effects would be reduced by the proposed outfall vs. existing Bay discharges because of design improvements and greater turbulence in the receiving waters.

Possibly an ocean discharge might affect abundance of one or more forage species important in the salmon diet. If salmon depended heavily on a single food organism, we should obviously be concerned with any influences an effluent might display toward such an organism. Merkel (1957) analyzed stomach contents of 1004 king salmon captured by trolling near San Francisco. Major dietary items were: anchovy 29.1%, rockfish 22.5%, euphausiids 14.9%, Pacific herring 12.7%, squid 9.3%, other fishes 7.3%, crab megalops, 4.0%. Size of

individuals did not affect food habits but seasonal differences were noted. King salmon thus subsist on a variety of organisms that are primarily pelagic. Confirming this conclusion, Cannon (1964) recommended trolling depths of just subsurface to eight to twelve feet above the bottom for salmon. If any changes occurred in pelagic communities in the immediate vicinity of the proposed outfall, any nearby salmon would undoubtedly substitute forage organisms that had become more plentiful for species that might display reduced numbers.

Striped Bass

The striped bass (Roccus saxatilis) like salmon, is anadromous and utilizes the San Francisco Bay-Delta system extensively for spawning. The species is not native but was introduced to San Francisco Bay from the east coast during the last century. The prime striped bass fishing areas lie within the Bay and our concern is with the relatively minor surf fishery along the San Francsico open coastline. Because the Bay fishery presently exists in waters receiving San Francisco (and many other) wastes, we would not expect the proposed outfall to exert damaging direct effects such as toxicities, adverse tastes or odors, etc., on striped bass in the surfline. In fact, if discharged wastes exert any adverse affects on striped bass within the bay, the proposed discharge in the Gulf of the Farallones would benefit the bay fishery. We have noted above the biological improvements observed in San Diego Bay after the City ceased using the area for waste disposal.

Scofield (1911) concluded that striped bass had catholic tastes and almost any small fishes or invertebrates might be found in a

stomach. Johnson and Calhoun (1952) analyzed stomach contents of 387 striped bass from San Francisco Bay. Principal dietary items in their specimens were shrimp 53%, and anchovy 39%. Skinner (1962) summarized several studies of food habits of striped bass. Apparently the striped bass is not dependent on one or two forage species and the proposed outfall should have negligible adverse effects on food supplies of this fish off San Francisco.

Market Crab

Market crab (*Cancer magister*) formerly occurred in San Francisco Bay in such numbers that at times they were considered a pest (Wakeman, 1871). The populations were apparently depleted by over-fishing and the fishery moved outside the Golden Gate sometime after 1880 (Skinner, 1962). Like other crustaceans, market crab have a planktonic existence as larvae lasting for months. San Francisco is near the southern limit of the fishery (and presumably of the main distribution of the population). Hence many juveniles settling off San Francisco probably originated from parents situated far to the north. Effects of discharged wastes on reproduction by crabs off San Francisco is thus of lesser concern than effects on larvae and the adult form. Influences of San Francisco wastes on crab larvae and adults is currently under investigation. Preliminary findings suggest no adverse effects at dilutions greater than 100 to 1.

Adults prefer shallow sandy bottoms at depths ranging from 25 to 90 feet. The animals burrow until only the stalked eyes and antennules are exposed. Apparently silty water or fine sediments interfere with activities such as respiration while buried because crabs recovered from muddy bottoms may be of poor quality (Skinner, 1962). Any discharge in the Gulf of the Farallones, there-

fore, should be designed to avoid extensive sludge deposits.

Adult crabs are primarily carnivorous. Food consists of fish, shrimp, small crabs, clams, and other animals, including corpses or portions of creatures recently dead. These broad food acceptances can be expected to aid survival of resident crabs near a proposed outfall if changes in benthic populations of infauna occur. Skinner (1962) reported that immature market crab occur abundantly in San Francisco and San Pablo Bays. We can therefore surmise that sewage effluents do not affect this species by direct means such as toxicity. The decline in the San Francisco fishery seems more likely the result of failure by crab larvae to settle in the Gulf of the Farallones, rather than any local change in environmental conditions adverse to the adult forms.

Lingcod

Lingcod (Ophiodon elongatus) are generally associated with rocky bottom and probably most catches in Square 455 are obtained near the Golden Gate, or off Seal Rocks. Skinner (1962) stated that no lingcod had been taken from within San Francisco Bay by commercial fishermen for at least thirty years and the catch came entirely from the ocean. This was not an indication that the species had disappeared from the Bay and Skinner noted that a special study would be needed to assess abundances accurately simply because there was no information available. Scott (1963) stated that "lingcod spawn in San Francisco Bay proper and then return to the ocean" but no supporting reference is given. Wilby (1937) described the lingcod as a voracious feeder. Juveniles consumed various crustacea including Pandalus and Neomysis, as well as herring. Adult stomachs contained sand lances, herring, flounder, dogfish, young lingcod, gray cod, whiting, crab, shrimp, and squid. Some specimens had

eaten small amounts of hydroids, eel grass, and even rocks, probably indicating adventitious ingestion while scooping up prey near the bottom. A rule of thumb for finding lingcod is "follow the herring". Quast (1968) reported from his analysis of seventeen lingcod stomachs almost exclusive recoveries of fishes and squid. He found anchovies only in individuals captures by hook and line (the lingcod possibly obtained the anchovies as a result of chumming). The rather cosmopolitan diet indicated for lingcod suggests that the species would easily alter its food if changes in supply followed operation of an outfall in the Gulf of the Farallones. We would not anticipate any deterioration in the Golden Gate area (probably the main source of lingcod in Square 455) as a result of the proposed outfall because the Richmond-Sunset discharge that presently releases right in the entrance to the Golden Gate would be discontinued. The proposed outfall would accept the effluent now being discharged by Richmond-Sunset and disperse it several miles away from the Golden Gate via improved design facilities.

English Sole

Published information concerning biology of the english sole (*Parophrys vetulus*) in the Gulf of the Farallones is scarce. Even the general literature on California flatfishes is limited. The most detailed exposition is Hagerman's (1952) treatise on biology of the Dover sole. Skinner (1962) reported that "tremendous numbers of immature flounders, sole, and sanddabs are present" in San Francisco Bay. He speculated that the Bay may serve as an important nursery for flatfishes as has been demonstrated for flounders and menhaden in Atlantic coast estuaries. As a group, flatfishes feed on a variety of invertebrates and fishes characteristic of sandy bottoms and to a

lesser extent, similar organisms from rocky bottoms (Quast, 1969, Limbaugh, 1955). Odemar *et al*. (1968) postulated a diet of benthic invertebrates for english sole. Cannon (1964) suggested ghost shrimp, fresh stripbait, clam siphons, rock worms, and small crabs as suitable bait for english sole. The best available evidence thus suggests that english sole and other flatfishes should be able to adjust to changes in food types if they were to occur in the Gulf of the Farallones.

Flatfishes appear to tolerate large outfalls as well as any group of fishes. Six of the ten most common fishes recovered by Carlisle (1969a) in his six-year trawl survey of Santa Monica Bay were flatfishes. English sole ranked fifth in recoveries out of 103 species listed. Santa Monica Bay receives effluent from the City of Los Angeles and is described in our section on southern California outfalls. The relatively high ranking of english sole in this very extensive survey provides assurance that the proposed outfall in the Gulf of the Farallones should have negligible effect on this species.

Albacore

Pacific albacore (*Thunnus alalunga*) are large pelagic fish that occur worldwide in temperate seas. In the North Pacific Ocean two important fishery areas exist (between Japan and the Hawaiian Islands and the west coast of North America). The species apparently prefers water temperatures between 62° to 67°F and performs extensive seasonal migrations to remain in its optimal range (Clemens and Craig, 1965). Clemens and Craig treated the entire west coast fishery as a single population and indeed believed that the whole North Pacific Ocean may be represented by only one population. Each year in June, albacore enter our west coast fishery

area from the south, move northward for several months, leave in a westerly direction between October to December, and enter the long line fishery lying between Japan and Hawaii. During cold years the coastal migration tends to concentrate fairly close to shore. During warm years, principal catches are made 50 to 300 miles from the coast. The albacore fishing fleet moves with the migration and thus covers a very wide territory during a single season.

Published statistics for albacore catches are not as detailed as the ten mile square grid used, for example, by Odemar et al. (1968). Clemens and Craig (1965) employed 60 mile squares to analyze the commercial albacore fishery and 20 mile squares for the partyboat fishery (Figure 8). Even these large grids suffice, however, to evaluate the albacore fishery in the Gulf of the Farallones. Seven of the eleven years from 1951 to 1961 produced small albacore catches (1 to 50 tons) during peak fishing periods for northern California (August to October) from the 60 mile square containing the Gulf (Clemens and Craig, 1965). In October and November 1951, tonnages rose to moderately higher levels (50 to 500 tons). Otherwise catches were nil in the 76 months of albacore fishing season between 1951 and 1961. Thus generally small quantities of albacore were commercially caught in 14 of the 76 months of the study. For the partyboat season (which is shorter than the commercial season) the Gulf of the Farallones yielded albacore in 6 months from a total of 53. Only one of the six months (September 1951) yielded albacore from the region of Square 455. In any case, the

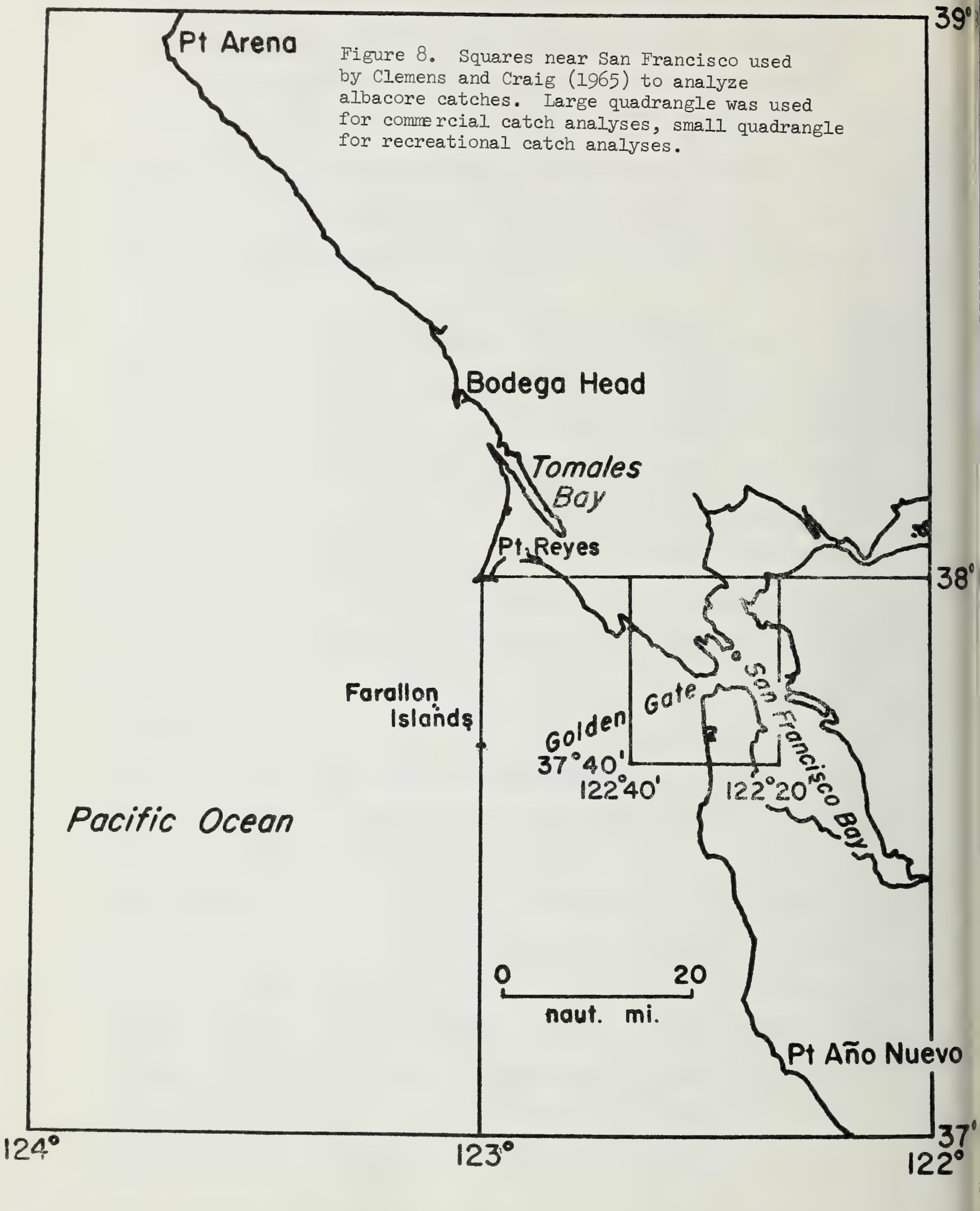

Figure 8. Squares near San Francisco used by Clemens and Craig (1965) to analyze albacore catches. Large quadrangle was used for commercial catch analyses, small quadrangle for recreational catch analyses.

partyboat fishery is quite small. Miller and Gotshall (1965) reported that only 176 albacore were caught from the entire 900 miles of California coast north of Point Arguello by partyboats during the four years 1958-1961.

Albacore feed on a wide variety of animals. Clemens and Iselin (1963) recovered 23 categories of invertebrates and 53 categories of fishes from a seven year study of albacore stomach contents. Principal dietary components included northern anchovy, rockfishes, jack mackerel, Pacific saury, barracudines, squid, euphausiids, amphipods, and heteropods.

The proposed discharge to the Gulf of the Farallones could thus at most have only an extremely minor effect on the albacore fisheries. Although substantial commercial landings are made in the San Francisco Area (Table 9), the contribution from the Gulf is miniscule. The diverse diet of the species indicates that the proposed discharge would not be likely to affect overall albacore food supplies. The proposed discharge would be sufficiently close to shore so that albacore would only rarely encounter even moderately high concentrations of effluent (i. e. dilutions of 100 to 1). Hence toxicity effects would be quite unlikely. The only conceivable influence would be generation of a hypothetical obnoxious odor or taste, excluding albacore from a very tiny portion of their total habitat.

Other Fauna

The coast from Point Reyes to Pigeon Point (i. e. Gulf of Farallones shoreline) has acquired a reputation as an impoverished area (for an example, see page 34 of the Association of Bay Governments Report, 1970). This opinion apparently arose from a three

year study by a committee established by the University of California Berkeley (UCB) to find a suitable location for their marine biological station (subsequently sited at Bodega Head). The committee's consensus was stated by Dr. Cadet Hand (presently Director of the Bodega laboratory) who noted that the Gulf coastline showed "a faunistic and floral depression (which we blame on the pollution, silt, etc., that flows out through the Golden Gate; Odemar _et al._, 1968). If this evaluation is correct, the Gulf may be a prime site for waste disposal. Presumably sensitive species here would long since have accommodated or vanished. An equally important corollary would be to avoid large waste discharges north or south of the Gulf, considered as rich, diverse coasts by the UCB committee.

Yancey (1970) identified organisms from sediment samples gathered by the University of California Berkeley in the Gulf of the Farallones. The only preservation given the samples was drying. Consequently only animals with shells or exoskeletons were readily identifiable. Ebert and Cordier (1966) conducted diving and trawling off Seal Rocks, took sediment samples, and trapped a number of species in crab pots.

Ebert and Cordier primarily sampled deep water within the San Francisco Bar (Figure 9). They reported coarse sediments containing abundant shell fragments and a negligible infauna. They concluded that the bottom was probably quite unstable. Yancey's samples came from the San Francisco Bar and from outlying areas (Figure 9). He reported medium-grained sediments from the Bar and fine-grained material beyond the Bar. His data clearly show a well-developed infauna throughout his sampling area. Yancey de-

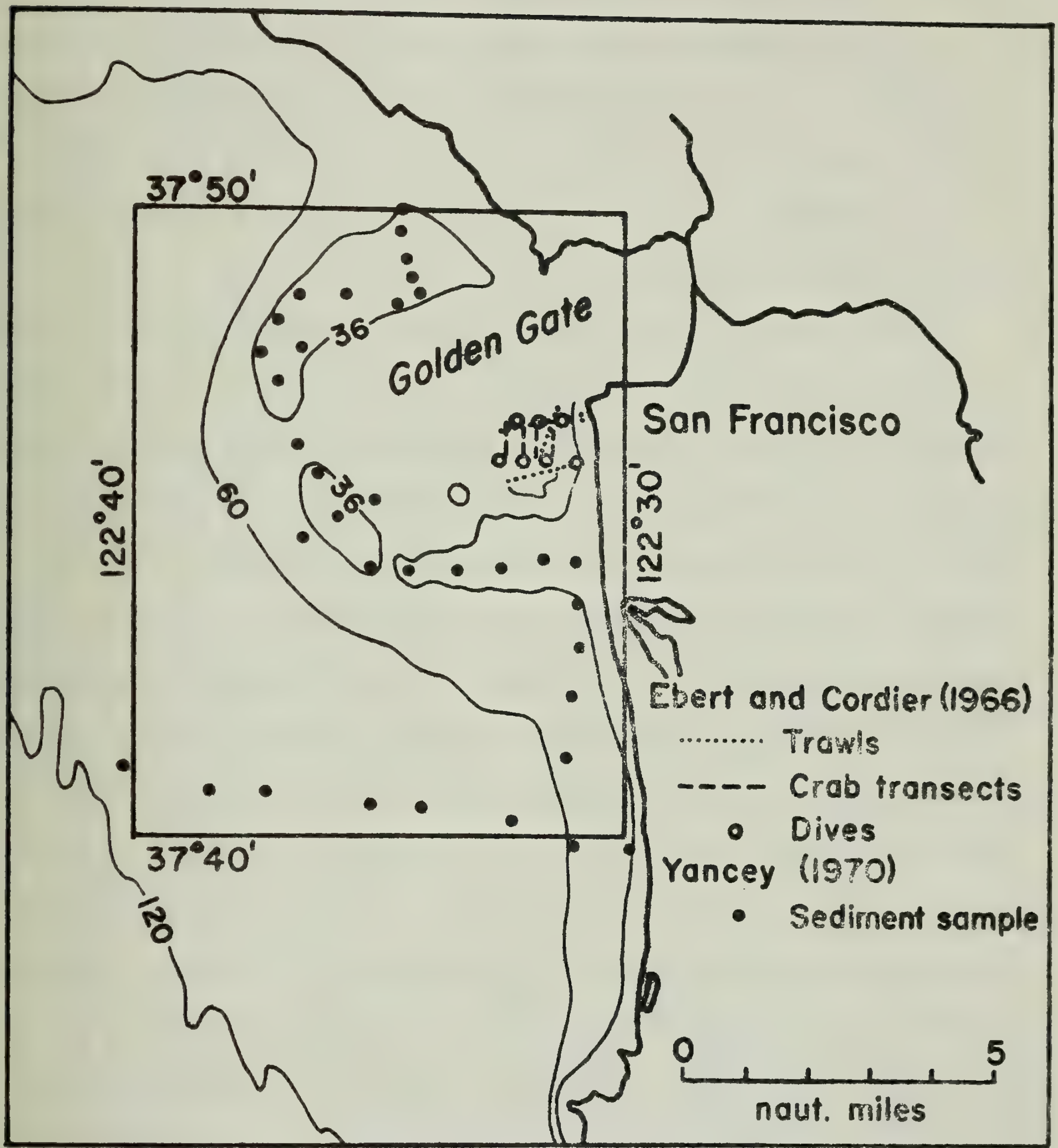

Figure 9. Golden Gate and inner Gulf of the Farallones, showing sampling stations of Yancey (1970) and of Ebert and Cordier (1966) used for our analysis of important fauna near the proposed ocean outfall discharge site. Relation of Square 455 to sampling stations is shown.

scribed typical associations for the Bar and for outlying areas and named them the "Bar Community" and the "Shelf Community". Although collection techniques were quite dissimilar, Ebert and Cordier's results were sufficiently different from Yancey's findings to justify the postulate that a third type of association or community exists in the Gulf of the Farallones. The third community type lies within the San Francisco Bar and we will designate it as the "Inner Shelf Community". We will call Yancey's "Shelf Community" the "Outer Shelf Community" to avoid confusion.

Both Yancey and Ebert and Cordier provided quantitative information on frequencies and abundances so that rough estimates of relative importance of each species can be attempted. Any precise comparisons would be hazardous because of the great variety of sampling methods used. We have grouped the species into three broad categories: Generally Important, Important at Certain Stations or Areas, and Not Important (Table 12). Species with high frequencies were usually classed as Generally Important. Species with moderate frequencies but high abundances were usually classed as Important at Certain Stations. Species with moderate to low frequencies and abundances were usually classed as Not Important. Account was also taken of the animal's niche (e.g. one or two large top carnivores may be just as important ecologically as several small filter feeders) and the sampling method (e.g. a baited trap may yield a biassed sample).

Of 94 species or groups reported by Yancey and Ebert and Cordier, 24 were considered as Generally Important, 15 as Important at Certain Stations, 53 as Not Important, and the importance of two groups could not be assessed (Table 12). Included among the Generally Important and Important at Certain Stations organisms are

TABLE 12

Species, genera, or groups reported within Square 455 from Gulf of Farallones surveys by Yancey (1970) and Ebert and Cordier (1966). "Recoveries" column indicates numbers of samples containing the organism or group and was primarily used to classify relative importance.

Species or Group	Listed by Yancey	Listed by Ebert	No. of Recoveries	Relative Importance: Genly. Imp.	Relative Importance: Imp. at certain stations	Relative Importance: Not Imp.
Foraminifera						
Elphidiella hannai	x		25	x		
Massilina sp.	x		1			x
Tricohyalus sp.	x		7		x	
Coelenterata						
Polyorchis penicillatus		x	4	x		
Bryozoa (identified only as distinct genera)	x		18		unknown	
Polychaeta						
Agglutinated tubes	x		1			x
Chitinous tubes	x		16	x		
Glyceridae		x	1			x
Goniadae		x	1			x
Nereidae		x	1			x
Crustacea						
Balanus crenatus		x	1			x
Balanus sp.	x		32	x		
Cancer antennarius		x	5		x	
Cancer anthonyi		x	1			x
Cancer magister		x	8	x		
Cancer productus		x	4		x	
Cancer sp.	x		15	x		
Crago franciscorum		x	5	x		

TABLE 12 (Continued)

Species or Group	Listed by Yancey	Listed by Ebert	No. of Recoveries	Relative Importance: Genly. Imp.	Relative Importance: Imp. at certain stations	Relative Importance: Not Imp.
Crustacea (cont'd)						
Crago nigromaculata		x	2			x
Mutilus sp.	x		1			x
Pagurus samuelis		x	2			x
Pseudophilomedes sp.	x		12		x	
Amphineura						
Mopalia sp.	x		1			x
Pelecypoda (Bivalvia)						
Axinopsida sericata	x		5		x	
Chlamys sp.	x		3			x
Clinocardium nuttallii	x		13	x		
Cooperella sp.	x		1			x
Hinnites multirugosus	x		1			x
Kellia laperousii	x		1			x
Macoma inconspicua (shell only)		x	1		unknown	
Macoma secta	x		1			x
Macoma sp.	x		16	x		
Modiolus sp.	x		13	x		
Mya sp.	x		1			x
Mysella sp.	x		3			x
Mysella tumida	x		19	x		
Nettastomella sp.	x		1			x
Nuculana sp.	x		4			x
Nuculana taphria	x		12		x	
Ostrea lurida	x		2			x
Pandora bilirata	x		3			x
Protothaca sp.	x		1			x
Protothaca staminea	x		9		x	
Siliqua patula	x		2			x

TABLE 12 (Continued)

Species or Group	Listed by Yancey	Listed by Ebert	No. of Recoveries	Relative Importance: Genly. Imp.	Relative Importance: Imp. at certain stations	Relative Importance: Not Imp.
Pelecypoda (cont'd)						
Siliqua sp.	x		12	x		
Solen sp.	x		1			x
Spisula cf. catilliformis	x		27	x		
Tellina bodegensis	x		23	x		
Tellina salmonea	x		23	x		
Transennella tantilla	x		7		x	
Yoldia sp.	x		1			x
Gastropoda						
Acmaea sp.	x		1			x
Acteon sp.	x		3			x
Acteocina sp.	x		1			x
Crepidula sp.	x		3			x
Epitonium sp.	x		1			x
Homalopoma sp.	x		1			x
Mangelia barbarensis	x		3			x
Micranellum sp.	x		2			x
Mitrella gouldii	x		4			x
Mitrella sp.	x		2			x
Nassarius fossatus (shell only)		x	1			x
Nassarius perpinguis	x		5		x	
Nassarius sp.	x		5			x
Odostomia sp.	x		5		x	
Olivella baetica	x		18	x		
Olivella sp.	x		6		x	
Polinices lewisi		x	1			x

TABLE 12 (Continued)

Species or Group	Listed by Yancey	Listed by Ebert	No. of Recoveries	Relative Importance: Genly. Imp.	Relative Importance: Imp. at certain stations	Relative Importance: Not Imp.
Scaphopoda						
Cadulus fusiformis	x		1			x
Cadulus sp.	x		2			x
Echinodermata						
Dendraster excentricus	x		23	x		
Pisces						
Amphistichus rhodoterus		x	1			x
Citharichthys sordidus		x	3		x	
Clupea pallasi		x	3		x	
Cymatogaster aggregata		x	4	x		
Engraulis mordax		x	4	x		
Genyonemus lineatus		x	4	x		
Hyperprosopon anale		x	3		x	
Hyperprosopon argenteum		x	2			x
Leptocottus armatus		x	3			x
Microgadus proximus		x	4	x		
Ophiodon elongatus		x	1			x
Palometa simillima		x	1			x
Paralichthys californicus		x	2			x
Parophrys vetulus		x	4	x		
Phanerodon furcatus		x	1			x
Platichthys stellatus		x	3			x

TABLE 12(Continued)

Species or Group	Listed by Yancey	Listed by Ebert	No. of Recoveries	Relative Importance: Genly. Imp.	Relative Importance: Imp. at certain stations	Relative Importance: Not Imp.
Pisces (cont'd)						
Porichthys notatus		x	1			x
Psettichthys melanostictus		x	4	x		
Raja binoculata		x	3			x
Rhacochilus vacca		x	2		x	
Spirinchus starksi		x	3			x
Squalus acanthias		x	5	x		
Triakis semifasciata		x	1			x

a number of animals common or frequently seen near outfalls in southern California (Polyorchis, Balanus, Cancer antennarius, C. productus, Modiolus, Odostomia, Olivella, Nassarius, Dendraster, Citharichthys, Cymatogaster, Engraulis, Genyonemus, Parophrys, and Rhacochilus; Carlisle, 1969a; Turner et al., 1966, 1967, 1968; personal experiences by the author). Many others do not occur commonly in southern California so that their sensitivity to sewage-seawater mixtures in this region cannot be judged. Several of these northern species have been recovered from San Francisco Bay, however, (Clinocardium, Macoma, Crago, Clupea, Leptocottus, Microgadus, Psettichthys, Squalus), often in substantial numbers (Aplin, 1966, Kaiser Engineers, 1968, Filice, 1954a, 1959; Sanitary Engineering Research Laboratory, 1964, 1965). Hence there is reason to believe that a substantial majority (i.e. at least 23 out of 39) of the important species in the Gulf of the Farallones Square 455 will not be affected adversely to a significant extent by the proposed discharge.

Summary of Predicted Outfall Effects

Important commercial and recreational fisheries occur in the Gulf of the Farallones. Our analyses indicate that salmon, market crab, and striped bass are quite important resources in the vicinity of the proposed discharge. Of lesser importance but nonetheless worth considering are lingcod, rockfish, english sole, and albacore. Literature relating to life histories, distribution, and feeding habits of these species suggests that influences of the proposed outfall on commercial and recreational fisheries will probably be small.

The Gulf of the Farallones supports a diverse fauna. Benthic studies indicate three principal subdivisions within our area of con-

cern. We have called these the inner shelf community, the bar community and the outer shelf community. A majority of the important species in these communities do not appear to be sensitive to discharged wastes, judging from their distributions in areas near submarine outfalls and in San Francisco Bay.

SECTION V

GENERAL SUMMARY AND CONCLUSIONS

Biological studies at many discharge sites along the Pacific coast have demonstrated moderate stimulating effects on plankton, highly adverse effects on seaweeds in certain instances where large urchin populations exist, while results on sedimentary fauna are variable, depending on waste volumes and dispersal characteristics of the receiving waters. Sedimentary fauna have been stimulated by discharge flows up to 100 mgd in the open sea. Greater flows may create substantial changes in diversity and biomass, particularly where significant sludge deposits accumulate. Very large discharges may also affect rocky substrate by deposits of fine organic-rich material, rendering surfaces unsuitable for settlement by larvae of the indigenous species. These problems appear to be minor or non-existent for discharges smaller than about 100 mgd.

The Gulf of the Farallones coastline was considered sufficiently impoverished so that the University of California Berkeley located its marine biological station at considerable distance from the campus in order to be well outside the Gulf region. Nonetheless the Gulf supports highly productive commercial and recreational fisheries as well as a diversified sedimentary fauna. A detailed analysis of the fisheries was undertaken to identify the principal components and to describe how catches have fluctuated. The information assisted in predicting possible influences that might result from a discharge into the Gulf.

Conceivable effects of a well diluted effluent were considered for salmon, striped bass, market crab, lingcod, english sole, and albacore. Influences were also examined for important members of the invertebrate communities recorded from near the proposed outfall site in the Gulf. Many of these organisms have been known to occur either in San Francisco Bay in recent times or in the vicinity of ocean outfalls elsewhere.

We have concluded that the ecological impact of the proposed outfall in Gulf of the Farallones will be small. Nearby sedimentary fauna may well be stimulated. We find no reason to believe that the outfall will have more than a slight impact (beneficial or adverse) on fisheries of the Gulf.

Judging from the biological literature on Pacific coast outfalls, the optimum ecological strategy for marine waste disposal appears to be dispersal of sewage from many small-to-medium size discharges scattered along the coast rather than from a few extremely large systems. The proposed discharge of the City of San Francisco into the Gulf of the Farallones thus appears to be preferable to combining this sewage with other bay-region wastes and injecting the total at one or two points located in rich biological areas outside of the Gulf.

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SECTION VII

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Survival of Dungeness Crab *(Cancer Magister)* **Larvae in Two Concentrations of San Francisco Sewage Effluent**

Prepared for Brown and Caldwell
by Marine Associates, San Diego, Division of Limnos Corporation, 1970

Marine Associates: Research Aims and Programs.

Marine Associates laboratory facilities are located at the San Diego Gas and Electric Company, South San Diego Bay power plant. The laboratory has the primary functions of researching the culture of larval marine organisms, effects of heated sea water effluent on survival and growth of marine organisms, and developing techniques of commercial culture of economically valuable aquatic species. The laboratory area contains approximately 20,000 square feet devoted to aquaria, large outdoor pools, and other experimental facilities.

Laboratory facilities are uniquely situated near the thermal outfall and cooling water intake canals of the power plant (Fig. 1), permitting thermal effluent, or normal bay water to be used in experimentation. A second unique situation is created by the close proximity of the Clair Engle experimental desalinization facility operated by the Office of Saline Water, Washington, D. C. Discharges of hot brine in various concentrations and temperatures are periodically released in the thermal outfall area. Research on the biological effects of hypersaline water on local bay biota can be undertaken in conjunction with thermal studies. The Clair Engle facility maintains an excellent chemical laboratory for determination of sea water quality, and the monitoring of plant effluents.

Marine Associates programs include: Research and delevopment of large scale culture of marine shrimp, utilizing thermal effluent for mass rearing of shrimp larvae. A 100 acre sea water pond is used for developing techniques of mass culture of juvenile and adult shrimp

Approximately 7,000 GPM of heated sea water are pumped into the pond creating optimum growing conditions for shrimp during most of the year. Adjunct studies on the culture of the Samoan Black Crab (a portunid crab attaining up to 18 pounds in weight) may show the feasibility of dual culture of crab and shrimp in the same pond.

Florida pompano have been reared at the laboratory for a full year. Excellent growth and survival of these fish have been obtained on a special diet formulated by Marine Associates. We anticipate these fish will spawn thereby permitting large scale pompano culture in California on a self sustaining basis.

Marine Associates has pioneered the culture of American lobster (Homarus) in California and is currently engaged in a program of large scale propagation of this species.

Figure 1

Marine Associates laboratory on South San Diego Bay at the San Diego Gas and Electric Company South Bay plant. The dike pictured separates the cooling water intake canal from the thermal outfall canal in the foreground.

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CULTURE OF DUNGENESS CRAB (Cancer magister) LARVAE IN TWO CONCENTRATIONS OF SEWAGE EFFLUENT.

1.0 Abstract:

Egg-bearing Dungeness crab were obtained from Oregon State Department of Fish and Game. Crabs were held in shallow, water tables until eggs hatched. Crab larvae were collected at night after they were concentrated under a 75 Watt bulb placed over the water. Larvae were divided into three, approximately equal lots and released into three aquaria each holding 900 gallons of sea water. A control aquarium contained sea water without sewage effluent. A second aquarium contained sea water and sewage effluent in the proportion 1: 200. A third aquarium contained sea water and sewage effluent in the proportion 1: 100 (one part effluent to 100 parts sea water)

Survival of crab larvae differed markedly in the three aquaria. Survival in the sea water aquarium was low, while survival in the aquaria containing sewage effluent was proportionately higher. The highest survival occurred at the highest concentration of sewage i. e. one part sewage in 100 parts sea water. The probable cause of differential survival in the three aquaria may be found in the proliferation of food organisms in response to the supply of micro-nutrients contained in sewage effluent.

The study indicated that the sewage effluent employed did not contain harmful, or lethal substances exerting an immediate, or long term detrimental effect on crab larvae.

Survival of larvae at the highest concentration of sewage remained high during the first 15 days after stocking. The reduction in numbers which followed the initial 15 day period was almost certainly caused by secondary (intra-specific predation) factors not related to effluent concentration. Ancillary studies indicated that sewage concentrations of 1:100, as employed, had no harmful effects on the growth and survival of American lobster (*Homarus americanus*) reared from hatching through four larval stages to the bottom dwelling form. A number of adult marine invertebrates, which entered the aquaria as planktonic larvae when the aquaria were filled, were observed on the walls of the aquaria following the study. Two species of finfish were also found in the aquaria following the study; the fish had entered the aquaria as eggs or larvae when the aquaria were filled, or were introduced with plankton food.

2.0 Conclusions:

2.1 A concentration of one part sewage effluent in 100 parts sea water is not harmful to Dungeness crab larvae.

2.2 Micro-nutrients in sewage effluent tests may have promoted the higher survival of crab larvae, reared under laboratory conditions than survival obtained in natural sea water.

2.3 A wide range of other marine invertebrate larvae can survive in 1 ; 100 concentration of the sewage effluent employed, and at least two species of marine finfish larvae were not adversly affected by these concentrations of sewage.

2.4 The sewage effluent employed in 1 : 100 concentrations seemed to be beneficial to survival to survival of many marine forms.

3.0 Method of experimentation:

3.1 Hatching and stocking of crab larvae:Egg-bearing Dungeness crabs were held in sea water at approximately 65° F (18° C) until eggs hatched. Crab larvae hatched periodically during the dates 3-20-70 and 3-27-70,from eggs carried by two or three emale crabs. During daylight, larvae were distributed throughout the water table in which they hatched. A 75 Watt light was employed at night to concentrate larvae into dense aggregations which could then be dipped up. The collected larvae were divided into three approximately equal lots and poured into the three aquaria used in the study. Successive lots of larvae were added in equal number to each of the aquaria each night during the first week hatching took place. The aquaria, therefore, came to contain larvae of differing age and size. The difference in age is not presumed to have any material influence on survival of late introductions; crustacean larvae, in general, are known to be highly individualistic in rates of individual growth.

3.2 Composition of sewage effluent: The sewage effluent employed in the study was a composite sample of sewage from major systems in the

San Francisco Bay area. Information received from BROWN and CALDWELL, Consulting Engineers, indicated that the composition of the effluent reflected the percentage contributed by the various systems in the total Bay discharge. The sewage effluent was air-shipped to San Diego in sealed, insulated carboys. The effluent was stored under refrigeration at 35^{0} F until used.

3.3 Sea Water employed in the study: San Diego Bay sea water was used to fill all aquaria. Salinity was adjusted to 32 ppt by the addition of sewage effluent and, or fresh water. Raw (i. e. without filtration) sea water was employed in the study to include living plankton organisms upon which crab larvae fed during the larval stage.

3.4 Supplemental feeding of larvae: Supplemental feeding with marine zooplankton and brine shrimp (*Artemia*) was employed in all aquaria after crab larvae were stocked to maintain food concentrations at a high level. Uniform food conditions were difficult to achieve because the phytoplankton (unicellular green alga) level varied in the three aquaria. Copepods obviously did less well in aquaria having lower nutrient (sewage) levels. Newly hatched brine shrimp (San Francisco brand) nauplii were added to all aquaria on a regular basis in an attempt to augment the food supply of crab larvae, particularly during the megalopa stage when food organisms larger than 400 Mu were reguired by larvae.

4.0 Aquarium preparation and sewage dilutions employed: Note of explanation. Successful culture of planktonic marine larvae of any type

requires maintaining a complex assortment and size range of predator-prey organisms under artificial conditions. Primary plankton constituents include the various unicellular green aglae and protozoans which form the food base for secondary (copepod) plankton elements. The copepods form the food base for tertiary predator organisms, such as crab larvae. In this study, the crab larvae constituted the apex predator which fed on the copepods. The maintenance of a stable ratio of unicellular algae, copepods, and crab larvae is difficult to achieve under the most ideal conditions.

Experience has shown that a very delicate balance exists between food resources and survival of the test animals. The food resources of the three aquaria could not be brought into balance by the very nature of the experiment. The present study, therefore, is concerned <u>solely with the effect</u> of two concentrations of sewage effluent on the <u>well being</u> of Dungeness crab larvae, and <u>not on the absolute rate of survival</u>. That is, an attempt was made to learn whether or not one of two concentrations of sewage would prove lethal, or harmful to crab larvae, as measured against survival of larvae in natural sea water.

The following proceedure was judged adequate for the purposes of this study:

4.1 Three aquaria (Fig. 2) of equal capacity and identical construction were each simultaneously filled with 900 gallons of sea water approximately one week prior to introduction of crab larvae.

4.2 Aquarium number one was drained of 9 gallons of sea water and 9 gallons of fresh water added to adjust salinity.

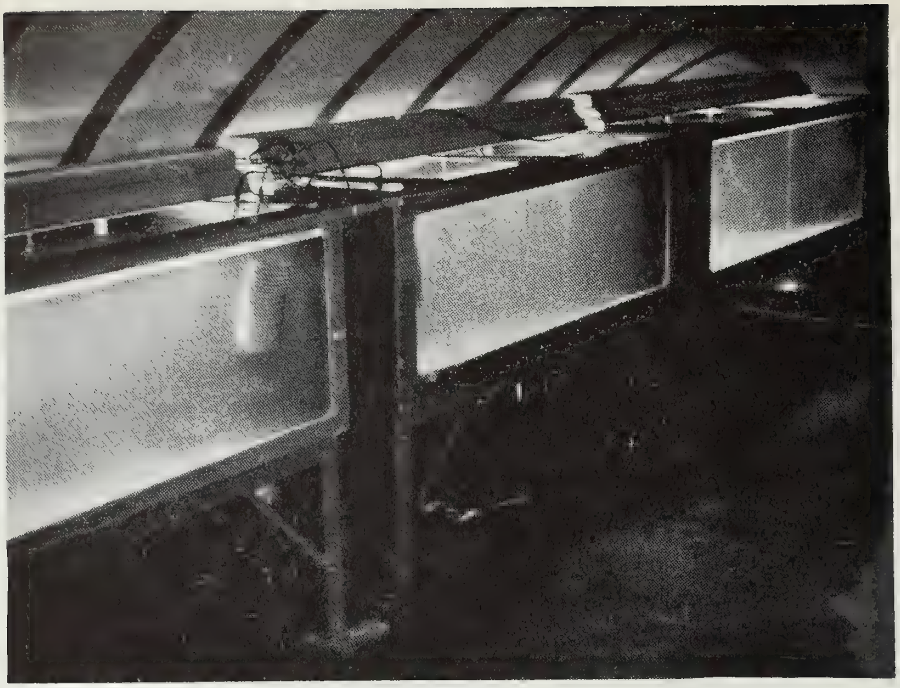

Figure 2

One-thousand gallon aquaria used in Brown & Caldwell crab experiments, showing 320 Watt fluorescent lamps.

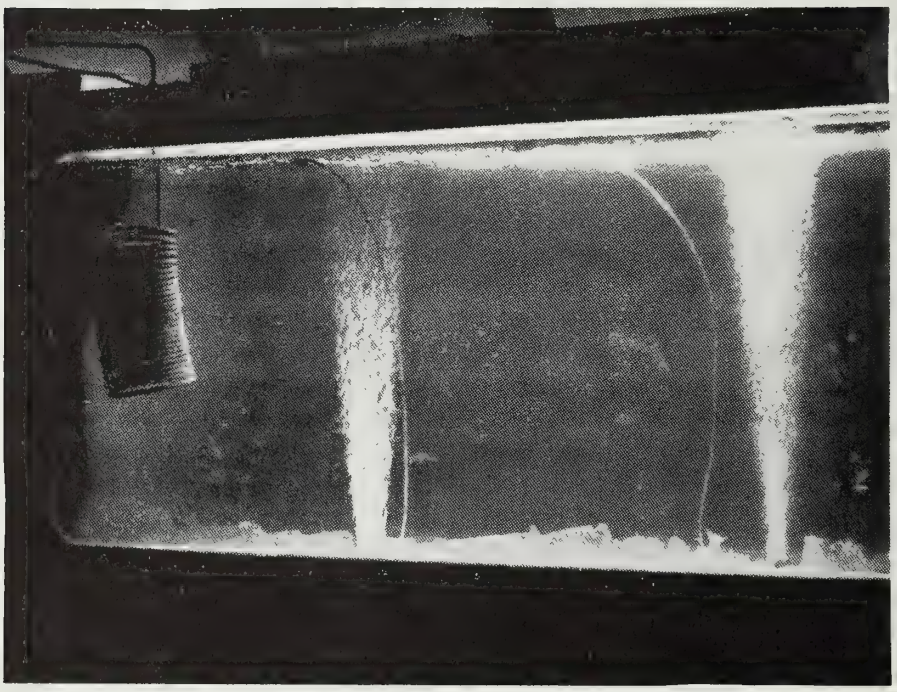

Figure 3

Airators promoting dispersal of crab larvae through vertical turbulance. Cooling coils visible installed during succeeding experiment with Cancer antennarius.

4.3 Aquarium number two was drained of 9 gallons of sea water and 4.5 gallons of sewage effluent and 4.5 gallons of fresh water were added to achieve a sewage concentration of approximately 1 : 200 (actual dilution was 1 : 199) and adjust salinity.

4.4 Aquarium number three was drained of 9 gallons of sea water and 9 gallons of sewage effluent added to achieve a dilution of 1 :100 (actual dilution was 1 : 99).

5.0 Environmental conditions in the aquaria.

5.1 Water quality: San Diego Bay water is naturally rich in phytoplankton and zooplankton. After filling the aquaria a rapid bloom of unicellular algae took place in aquaria containing sewage effluent, followed by a rapid increase in the number of zooplankton organisms. The primary zooplankter present was the harpactacoid copepod *Tigriopus*. The control aquarium, containing only sea water, developed only a moderate population of zoo- and phytoplankters.

5.2 Initial stocking of food organisms. To increase the food base, live zooplankton was collected in South San Diego Bay by towing a fine mesh (80 Mu.) net through the water. The collected plankton was transported to the laboratory in tubs of sea water. Plankton was separated from sea water in the laboratory by pouring through a fine net and the concentrated plankton divided and poured into the aquaria. Additional collections of plankton were made each day and concentrated food organisms added to each aquarium during the period of the study.

Survival of food organisms was low in the sea water (control) aquarium because of low algal density. Survival was higher in aquaria

containing sewage (and a high phytoplankton development).

5.3 Feeding late stage crab larvae: An increased number of brine shrimp nauplii were introduced into all aquaria during later crab stages, and particularly during the megalopa stage when larger food organisms are eaten by crab larvae.

5.4 Illumination of aquaria: Aquaria were well lighted by a bank of 4, eight foot long fluorescent light tubes suspended over each aquarium. A total of 320 Watts illumination was achieved at the water surface of each aquarium. Penetration of light into aquarium water was, however, not uniform in each of the aquaria owing to the differential growth of unicellular algae, which was most dense in the 1 : 100 sewage concentration.

5.5 Temperature. Water temperature in the aquaria varied uniformly by 2 - 3 degrees above and below a mean of 65^0 F (18^0 C). Diurnal as well as day to day temperature fluctuations occurred as weather conditions dictated. Refrigeration equipment was not at hand at that time to regulate temperature.

5.6 Airation: All aquaria contained three air stones (Fig. 3) which provided constant movement of water and tended to disperse crab larvae to all portions of the aquarium.

5.7 Maintenance of salinity levels: The constant inflow of air through the aquaria caused evaporation of sea water, particularly during Santa Ana conditions which occurred during the study. A slow trickle of fresh water was used to restore the volume of aquarium water to original levels, and hence to original salinity.

6.0 Experimental results:

6.1 The control aquarium: The sea water aquarium remained relatively clear throughout the 80 day study. A rapid mortality took place among crab larvae during the first 10 days after stocking. It was difficult to maintain high food levels for crab larvae in the absence of a high phytoplankton supply, therefore predation very likely took place among crab larvae. A continuous, but less obvious mortality continued throughout the zoeal stages and very few zoea metamorphosed to the megalopa stage. At least three megalopa underwent a final molt to the first crab instar. The juvenile crabs attempted to swim, or climb off the bottom and were observed on the upper walls of the aquarium where filaments of algae (*Enteromorpha*) grew. It seemed obvious that the clean bottom of the aquarium offered little attraction (or food source ?) to the first bottom stage crabs.

Although every effort was made to supply the control aquarium with adequate food supplies for larvae, difficulties were experienced in keeping the introduced food organisms alive. The zooplankton added to the aquarium simply overloaded their food resources and consequently died off rapidly. The survival of crab larvae obtained under what was presumably better than natural conditions, probably was similar to that occuring in nature, i. e. only one or two larvae surviving per hundred-thousand spawned.

6.2 Sewage effluent - sea water; 1 : 200 dilution. The biological richness of this aquarium was considerably above the control aquarium. A moderately dense growth of unicellular algae occurred during the first three days after the aquarium was filled. A large number of marine copepods were observed on the aquarium glass and on the surface of the water. Transparency of water remained about 30 Cm during the 40 day

duration of the experiment in this aquarium. Some reproduction of introduced food organisms was apparent and density of food organisms remained high until crab larvae attained late zoeal stages. A gradual diminishing of the food supply was observed when crab larvae began preying on the larger food organisms. Since adult copepods (and brine shrimp) were selected as food by crab larvae, little reproduction took place.

This experiment was terminated 40 days after the initial introduction of larvae. The remaining zoeal and megalopa stage larvae were combined with those in the aquarium containing a 1 : 100 sewage concentration.

6.3 Sewage effluent - sea water, 1 : 100 dilution. A marked increase in unicellular algae was observed to take place in this aquarium during the first three days after the aquarium was filled. Although a high concentration of grazing copepods was always present, a reduction in phytoplankton was not observed during the experiment. At the conclusion of the experiment (after crab megalopa had metamorphosed to juvenile crab) this water continued to exhibit a high growth potential for algae. The bright green color of the algae indicated a high rate of nutrition and reproduction. Transparency of water remained about 10 to 15 Cm during the 74 days of the experiment.

The opaque quality of the aquarium water made observation of crab larvae very difficult, however, large numbers of crab larvae could be seen swimming along the aquarium glass by the 40th day after initial introduction. Since survival of crab larvae was observed to be

highest in the 1 : 100 sewage concentration, the larvae in the aquarium containing 1 : 200 sewage concentration were collected at night by light and added to those in the 1 : 100 sewage concentration. This reduced the considerable labor involved in collecting large quanities of food organisms each day for three aquaria.

The aquarium containing 1 : 200 sewage concentration was drained and a layer of sand, shells, and organic debris collected in San Diego Bay was spread over the bottom in an attempt to create a juvenile crab habitat. All of the water (with crab larvae and food organisms) in the 1 : 100 sewage concentration aquarium was siphoned into the aquarium containing the more or less natural sea bottom.

Several days after a number of first instar crabs were observed (6-4-70) in the aquarium, the water and remaining crab larvae were siphoned off and fresh water added. As the water cleared and the bottom could be observed, a large number (25 to 50) of crabs were seen hiding among stones and clumps of sessile aglae. The juvenile crabs seemed sensitive to light and many more could be observed at night when the light was turned on .

7.0 Conclusions based on the study.

7.1 Survival of crab larvae. Survival of crab larvae seemed to be proportional to sewage concentrations employed. Survival was lowest in natural sea water, and highest in the highest concentration of sewage effluent - sea water mix. This proportionate survival was undoubtedly due to the concentration of trace elements which fostered the growth of primary food organisms (unicellular algae and protozoans) and the secondary food organisms (copepods). The apex predator (Dungeness crab larvae) benefited most when its food supply was not only abundant, but well fed. On the basis of survival alone, it was apparent that the sewage employed in the experiments did not contain a concentration of substances lethal to Dungeness crab larvae. The highest concentration of sewage effluent employed produced the highest relative survival in larvae.

7.2 Lethal limits of sewage effluent. A range of tolerance for the type of sewage employed in this study was not established. The study did show that the sewage in concentrations of one part per 100 parts sea water was not harmful to Dungeness crab larvae, nor to a variety of other larval marine organisms.

A further series of test rearings of Dungeness crab larvae at sewage concentrations of 1 : 100; 1 : 50; 1 : 25 , Etc., will be necessary to establish lethal limits.

8.0 Remarks and observations.

During the above described study, a variety of extraneous marine

organisms were inadvertently subjected to the effects of sewage in the two concentrations employed. Since all of the organisms entered the aquaria in the larval stages (except for adult copepods) it may be assumed that sewage concentrations of one part per 100 parts sea water are not detrimental to the following partial list of identified organisms:

Vertebrates:	Top smelt, _Atherinops_ Goby, _Gillichthys_
Invertebrates:	Harpacticoid copepods, _Tigriopus_, _Tisby_ Barnacle, _Balanus_ Shrimp, _Spirontocaris_, _Caprella_ Mussel, _Mytilus_ Crabs, _Pachygrapsis_, _Hemigrapsis_ Miscl. tunicates, annelids, isopods, bryozoans,

The American lobster (_Homarus americanus_) was purposely exposed to 1 : 100 concentration of San Francisco Bay sewage. A large number of lobster hatched after the crab rearing experiment was underway and the opportunity was taken to determine the effect of sewage on the survival of lobster larvae. The gross environmental conditions in the 10 gallon aquaria used were approximately similar to those in the 1,000 gallon aquaria used to rear crab larvae. The results of culturing lobster larvae in 1 : 100 concentration of sewage effluent, and in natural sea water, were virtually identical. At a density of 4 larvae per gallon, 42 lobster (100 percent) survived in the 1 : 100 sewage aquarium, and 40 larvae (95 percent) survived in normal sea water.

9.0 Schedule of observed events.

9.1 Water samples received 2-20-70 via air freight. Four carboys containing 5 gallons each packed in insulated containers. All samples stored under refrigeration at 35^0 F.

9.2 Three aquaria set up for culture of crab larvae. Aquaria filled 2-21-70 with sea water and sewage concentrate 1 : 100; 1: 200.

9.3 Six gravid Dungeness crabs received from Oregon State Game Commission via air freight 3-14-70. Crabs placed in sea water at 65^0F. (One crab died in shipment, one crab died following day).

9.4 Crab larvae observed in sea water trough 3-20-70. Larvae concentrated at night (11 - 1 P M) by use of 75 Watt light and collected. Larvae divided into three approximately equal lots and introduced into three aquaria. Successive lots of larvae added to the aquaria on succeeding nights as larvae continued to hatch. No larvae added to aquaria after 3-27-70.

9.5 Survival of larvae difficult to determine in aquaria containing sewage because of dense algal bloom. Interval 3-20-70 through 3-23-70 survival of larvae seemed high in all aquaria, but fell off markedly in control aquarium by 4-2-70.

9.6 Two berried crabs died 4-2-70. Of two remaining, one had early stage eggs, and one was the first to hatch eggs on 3-20-70.

9.7 4-1-70 first zoeal stage larvae molted to second stage (observed in 1 : 200 sewage aquarium).

9.8 4-2-70 Second stage zoea seen in 1 : 100 sewage aquarium.

9.9 4-8-70 Third stage zoea seen in 1 : 100; 1 : 200 aquarium.

9.10 Second stage zoea observed 4-10-70 in control aquarium.

9.11 Fourth stage ? zoea observed in 1 : 100 and 1 : 200 aquaria 4-18-70. Stage of development not observed in control aquarium.

9.12 4-28-70, fifth stage larva observed in 1 : 100 and 1 : 200 aquaria.

9.13 5-13-70, First megalopa stage observed in 1 : 100 aquarium; 5-15-70 many megalopa observed in 1 : 200 aquarium

9.14 6-4-70, First crab instar ? observed on bottom of 1 : 100 and 1 : 200 aquaria

9.15 6-11-70, First? crab instar observed on bottom of control aquarium

9.16 All larvae and crabs in control and 1 : 200 aquaria transferred to 1 : 100 aquarium. No count made on number because transfer was made by siphon. Three metamorphosed crabs captured in control aquarium were transferred to 1 : 100 aquarium where a sea bed had been established.

9.17 Total time from hatching to first observed juvenile (first crab instar) crab was 74 days.

10.0 Discussion:

As stated earlier, the test rearings reported here had the primary objective of establishing levels of tolerance for the specific (San Francisco) sewage effluent employed in the test. Quite obviously, the rearings of crab larvae undertaken in 1 : 100 and 1 : 200 concentrations of sewage failed to establish a base tolerance level since larvae survived and grew well at both concentrations in comparison to the sea water control. The differential survival observed, almost certainly related to environmental parameters indirectly attributable to sewage concentration, i. e. productivity of the water mass. The same effect could have been obtained by the addition of any suitable fertilizer to sea water; this is a common practice in larval culture.

The determination of absolute rates of survival (and growth)of larval organisms in relation to temperature, salinity, and presence of limiting elements (environmental and chemical) is difficult to establish under the best of experimental conditions. This is why, in general, the majority of attempts at larval culture are aimed at taxonomic studies in which succeeding larval stages are described. The main requirement here is a series of growth stages, not necessarily in the same individual, which provide morphological data. Nearly all published material on rearing techniques and duration of larval stages in *Cancer magister* reflect the taxonomic approach to larval studies in this species (Pool, 1966; Mir,1961) and in the blue crab (*Callinectes sapidus*) (Lochhead, 1942; Hopkins, 1943, 1944; Sandoz and Hopkins, 1944; Costlow, 1959).

In a recent work, Reed (1969) studied the effect of temperature and salinity on survival and growth of *Cancer magister* reared under

laboratory conditions, but no attempt was made to obtain high survival of crab larvae. This study was valuable, however, in that several food organisms were investigated for nutritional qualities and the importance of food quality in relation to survival of crab larvae establsihed. That is, some food organisms were found to be acceptable to Dungeness crab larvae (promoted survival) and other were not. More importantly,the approximate time between hatching of larvae and first observed megalopa stage was reported by Reed to be 45 days at a temperature of 17.8^{0}C. This correlates well to the approximately 43 days development observed in our studies which took place at a mean temperature of 18^{0} C. Reed obtained survival of approximately 80 percent at what he concluded were optimum temperatures (10.0 - 13.9^{0}C), while our results were at least an order of magnitude lower in the most productive aquarium. It is our feeling, however, that the large volume of water employed in our tests came close to simulating natural conditions where survival is expected to be lower.

The determination of rate of survival of crab larvae in various concentrations of sewage effluent will, therefore, require some means of optimizing the number and quality of food organisms available to crab larvae. A test situation which stipulates various concentrations of sewage, i. e. various nutrient levels, suffers at the outset from lack of test uniformity. It is suggested that absolute rates of survival for crab larvae reared in various concentrations of sewage can (only) be established by creation of a uniform media in which larvae are reared.

This requires an analysis of primary nutrient level (total nitrogen, phosphorus, carbon, and B_{12}) in test sewage be established, and proportionate levels of these growth parameters be established in aquaria containing lower levels, including the sea water control. With this methodology, the limiting elements in the sewage effluent employed for testing will become apparent should they exist.

It is further suggested that future studies on survival of crab larvae in sewage effluent also make provision for reporting unicellular algal cell counts per cubic centimeter of water, as an index of productivity. This is the only true measure, along with invertebrate food levels, which can be correlated with well being of marine larvae being cultured under laboratory conditions. This will result in a somewhat more complicated (and expensive) study, but will will result in more meaningful, overall results having wider application in the field.

10.1 Literature cited.

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